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EARTH NOISE AT VERY LONG PERIOD EXPERIMENT STATIONS. TECHNICAL REPORT NUMBER 3. VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH

Sidney R. Prahl

Texas Instruments, Incorporated

Prepared for:

Air Force Technical Applications Center
Advanced Research Projects

27 November 1974

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EARTH NOISE AT VERY LONG PERIOD EXPERIMENT STATIONS

TECHNICAL REPORT NO. 3

VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH

Prepared by
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This report presents the results of a study of the noise characteristics of eleven VLPE stations. For the period from January 1972 through March 1973, 1503 one-hour vertical component and 846 one-hour three component noise samples were processed and analyzed for short- and long-term vertical component noise trends, three component spectra, and two-component coherence spectra.

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19. continued

Three Component Noise Spectra
Vertical Component RMS Noise Amplitudes

20. continued

Overall data quality was poor during January 1972 through March 1973. Only about 50 percent of the data was usable. Within a stable earth noise minimum of 22-42 seconds period, the horizontal component spectra were remarkably similar to the vertical component spectra in amplitude, variability, and spectral shape. All components of all VLPE stations were only weakly coherent suggesting that the average noise field resulted from isotropic noise.

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This report presents the results of a study of the noise characteristics of eleven VLPE stations. For the period from January 1972 through March 1973, 1503 one-hour vertical component and 846 one-hour three component noise samples were processed and analyzed for short-and-long-term vertical component noise trends, three component spectra, and two-component coherence spectra.

Overall data quality was poor during January 1972 through March 1973. Only about 50 percent of the data was usable. Within a stable earth noise minimum of 22-42 seconds periods, the horizontal component spectra were remarkably similar to the vertical component spectra in amplitude, variability, and spectral shape. All components of all VLPE stations were only weakly coherent suggesting that the average noise field resulted from isotropic noise.

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SECTION I
INTRODUCTION

This report presents the results of a study of broadband earth noise at Very Long Period Experiment (VLPE) stations. The specific objectives of this investigation were:

- The determination of the long-term (seasonal) behavior of the vertical component noise field
- The investigation of the three component noise spectra
- The calculation of intercomponent coherence.

These objectives were accomplished by processing and examining 1503 one-hour vertical component noise samples and 846 one-hour three component noise samples from all VLPE stations for the period from January 1972 through March 1973. These data are discussed in Section II. In Section III the seasonal variations of the vertical component noise data were analyzed using instrument response corrected root-mean-square (RMS) amplitudes. The three component noise data were investigated, in Section IV, through the measurement of the spectral power densities and the coherence spectra between components. Section V presents the conclusions derived from these results.

SECTION II
DATA BASE

A. VLPE NETWORK

The VLPE network consists of eleven high-gain three component long-period seismograph systems with oriented components in the standard vertical (V), north-south (N), and east-west (E) directions. The responses (sensitivities) of the instruments are shaped to resemble the inverse of the average earth noise spectrum over the period range of 10-100 seconds. This allows peak recording magnification to occur in the minimum noise band of 30-40 seconds period (Murphy, et al., 1972).

Table II-1 lists the designators and locations of the VLPE stations. The operational status of the network varied throughout the test period. Changes included the termination of station FBK in April 1972 and the establishments of station ZLP in November 1972 and station MAT in December 1972. Station OGD changed its digital magnetic field tape format in July 1972. However, appropriate changes in the data merge program to handle the revised format were not initiated soon enough to utilize much of the data from this station. Stations CTA, CHG, TLO, and EIL reported equipment difficulties in the first three months of 1972.

B. DATA ACQUISITION

Figure II-1 illustrates a simplified flow chart of the noise data processing procedure. All available VLPE digital magnetic field tapes were merged to generate library tapes. Preliminary Determination of Epicenters (PDE) Bulletins, the Seismic Data Analysis Center/Large Aperture Seismic

TABLE II-1

VERY LONG PERIOD EXPERIMENT
STATIONS AND LOCATIONS

Station	Mnemonic Designator	Numeric Designator	Latitude	Longitude
Charters Towers, Australia	CTA	1	20.09 S	146.26 E
Chiang Mai, Thailand	CHG	2	18.79 N	98.98 E
Fairbanks, Alaska	FBK	3	64.90 N	148.01 W
Toledo, Spain	TLO	4	39.86 N	4.02 W
Eilat, Israel	EIL	5	29.55 N	34.95 E
Kongsberg, Norway	KON	6	59.65 N	9.59 E
Ogdensburg, New Jersey	OGD	7	41.07 N	74.62 W
Kipapa, Hawaii	KIP	8	21.42 N	158.02 W
Albuquerque, New Mexico	ALQ	9	34.94 N	106.46 W
La Paz, Bolivia	ZLP	10	16.50 S	68.13 W
Matsushiro, Japan	MAT	11	36.54 N	138.21 E

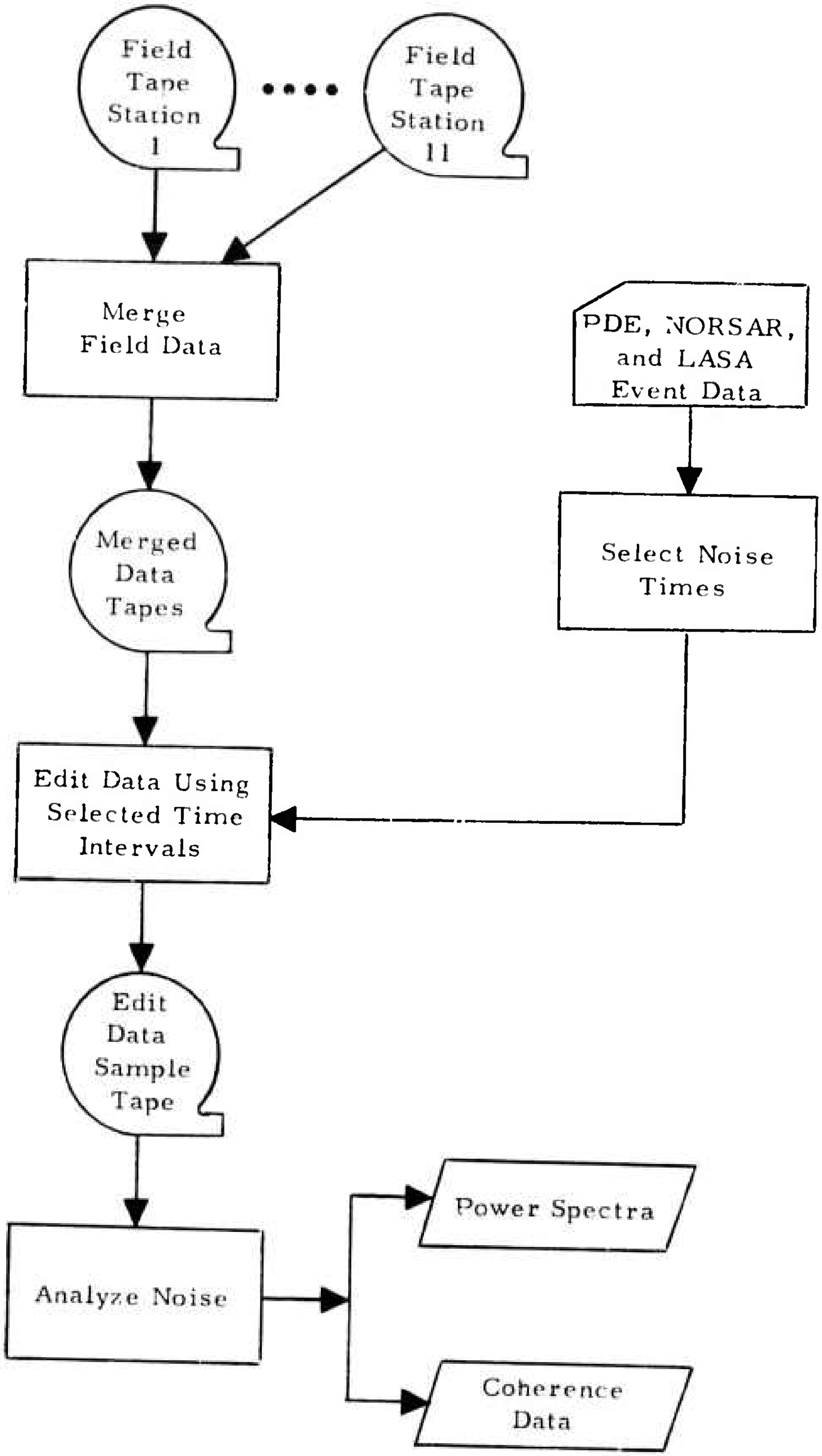

FIGURE II-1

DATA PROCESSING FLOW CHART

Array (SDAC/LASA) Bulletins, and the Norwegian Seismic Array (NORSAR) Seismic Event Bulletins were searched from January 1972 through March 1972 for one-hour time intervals during which no seismic events were reported. The one-hour noise samples, one every day per VLPE station, were then edited from the library tapes for further processing which included the following steps:

- The data were Fourier transformed in seven 256 time point (512 seconds) segments for all components. A three point Hanning smoothing operator was applied to the transforms increasing their stability at the expense of independence (i.e., the frequency increment between successive independent measurements was doubled: Δf = 0.003906 Hz).
- Crosspower spectral matrices for each segment were generated and stacked over all seven segments for a bandwidth of 0.0 to 0.14 Hz.
- Power density spectra for each component at frequencies of 0.016 to 0.075 Hz (13.5 to 62.5 seconds period) were calculated, corrected for instrument response, and converted to RMS ground motion amplitudes.
- Two-component coherence between the three components were determined.

DATA QUALITY

Each noise sample was subjected to a series of amplitude and power density tests to determine if it contained spikes, transients, noise of abnormally long period, or seismic signals. Over 450 noise samples thus rejected and 100 acceptable noise samples were visually examined to insure the validity of the acceptance criteria. It was found that all rejected noise samples were indeed unacceptable and that approximately 10 percent of the acceptable noise samples contained non-seismic noise abnormalities.

The accepted noise samples were divided into two categories: vertical component noise data in cases where both horizontal components were unacceptable, and three component noise data for which the vertical and two horizontal components were acceptable.

The test period from January 1972 through March 1973 overlapped time periods previously reported by Alsup and Becker (1973a; 1973b) and Lambert et al. (1973). The data from these reports were updated to conform to current specifications and acceptance criteria and are included in this report.

Table II-2 gives a summary of the number of data samples available from each VLPE station during the test period. Also included are the total numbers of acceptable three component and vertical component samples and the percentages that they represent.

Fifty-five percent of all available data samples had acceptable vertical component noise data. This number agrees with the percentage of seismic signal data available as reported by Lambert et al. (1973). Station MAT had a low percentage due to equipment difficulties during the limited time between installation of the station and the end of the test period.

Thirty-one percent of all available data samples had acceptable three component noise data. Stations TLO, EIL, and ZLP had very low percentages of acceptable three component noise data. Apparently the horizontal instruments at these locations were not operating reliably during the test period.

TABLE II-2

NOISE DATA STATISTICS OF VERY LONG PERIOD EXPERIMENT STATIONS

Sample Description	VLPE Stations										
	CTA	CHG	FBK	TLO	EIL	KON	OGD	KIP	ALQ	ZLP	MAT
Total Number of Available Noise Samples	290	247	116	280	278	444	160	365	320	142	92
Total Number of Acceptable Vertical Component (VC) Noise Samples	140	124	79	172	134	238	81	254	188	61	32
% $\frac{\text{Acceptable VC Noise Samples}}{\text{Available Noise Samples}}$	48	50	68	61	48	54	51	70	59	43	35
Total Number of Acceptable Three Component (3C) Noise Samples	113	93	43	36	29	190	75	89	134	23	21
% $\frac{\text{Acceptable 3C Noise Samples}}{\text{Available Noise Samples}}$	39	38	37	13	10	43	47	24	42	16	23

SECTION III

VERTICAL COMPONENT NOISE ANALYSIS

A. ANALYSIS PROCEDURE

The data acquisition procedure for the vertical component noise data was briefly discussed in Section II. More specifically, the instrument corrected spectral power density estimates of the vertical component were integrated over narrowbands corresponding to 17-25 seconds period, 20-40 seconds period, and 30-40 seconds period to yield RMS ground motion amplitudes:

$$RMS_a^b = \Delta f \sqrt{\sum_{i=a}^{b} |A(f_i)|^2 \; C(f_i)^2}$$

where:

$|A(f_i)|^2$ = discrete Fourier transform spectral density estimate at frequency f_i

Δf = elemental frequency interval (Δf = 0.003906 Hz)

a = initial frequency index

b = final frequency index

$C(f_i)$ = instrument response correction at frequency f_i.

The instrument responses were obtained from the Seismological Center at Albuquerque, New Mexico, and were displayed in Lambert and Becker (1973) and Lambert, et al., (1973).

B. RESULTS

In previous reports (Alsup and Becker, 1973a; 1973b and Lambert et al. 1973) three overlapping noise bands of 17-25, 20-40, and 30-40 seconds period were used to study earth noise characteristics. The 17-25 seconds period band includes the period (20 seconds) at which M_s calculations are performed. The 30-40 seconds period band is centered around the periods having the lowest RMS noise amplitudes. The 20-40 seconds period band encompasses the periods (20, 30 and 40 seconds) at which signals are normally detected. The three bands are intended to show trends, contrasts, and variabilities in the RMS noise.

Figures III-1 through III-11 show 1503 calculated RMS vertical component noise amplitudes in millimicrons (mμ) plotted versus Julian day of 1972 and 1973 for the 17-25, 20-40 and 30-40 seconds period bands for each VLPE station. Consecutive days of data are connected by lines. The mean RMS amplitudes and standard deviations calculated over the entire test period are listed for each period band and station in Table III-1. The average RMS noise levels in the 17-25, 20-40 and 30-40 seconds period bands for all VLPE stations during the test period were 14.5, 10.1, and 4.5 mμ respectively, showing that the minimum 'noise window' is centered around the 30-40 seconds period band.

The RMS amplitudes at most stations frequently rose above the mean level by factors of three to five spanning one to three days before returning to the mean level. Similar short-term fluctuations have been observed at NORSAR. The mechanism that produced these sudden rises above the mean level at NORSAR seems to be strongly correlated with weather conditions (Laun et al. 1973). It is suggested that the fluctuations observed at VLPE stations are also due to local or near-regional weather conditions.

SITE 1. CTA

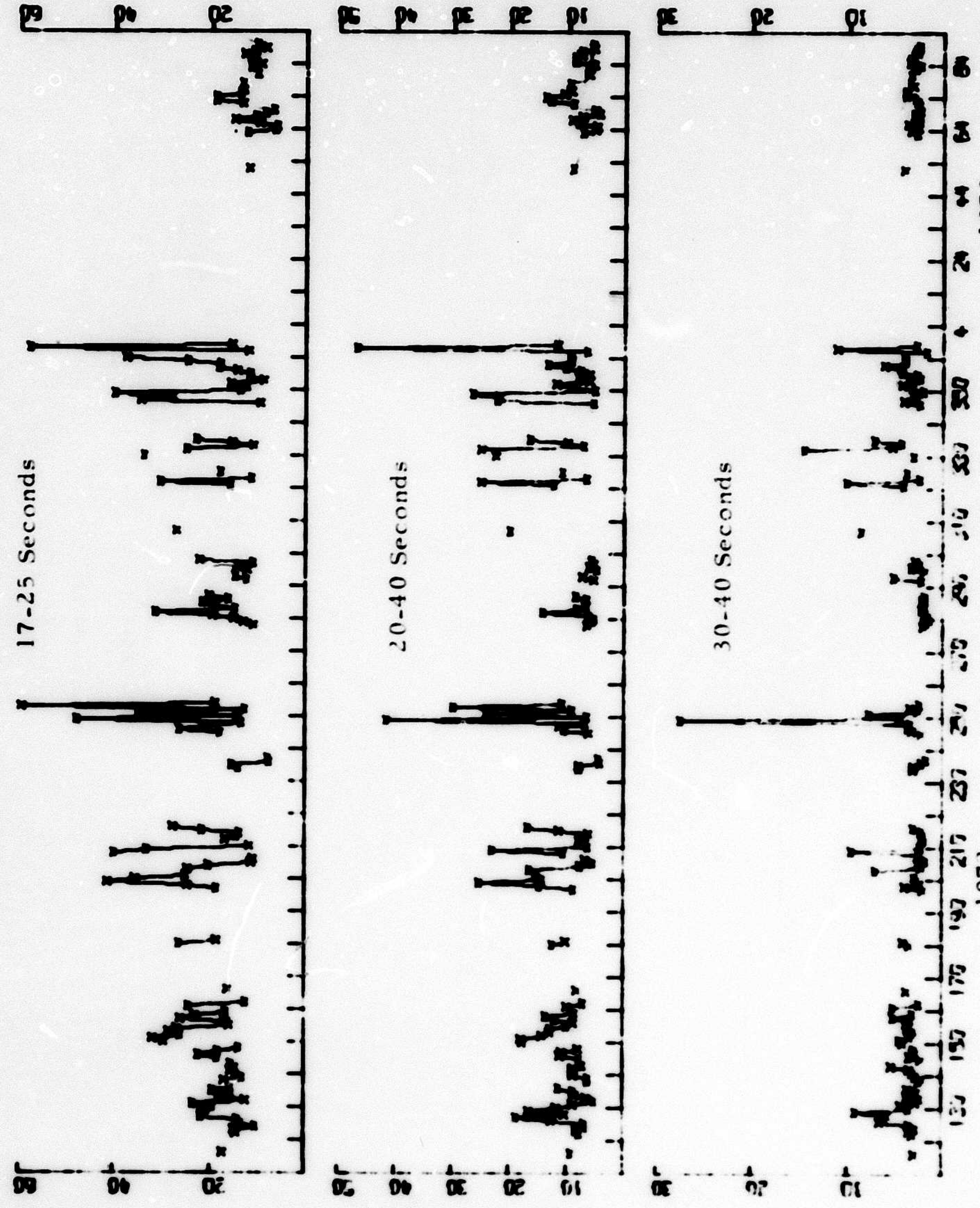

FIGURE III-1

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION CTA

SITE 2. CHG

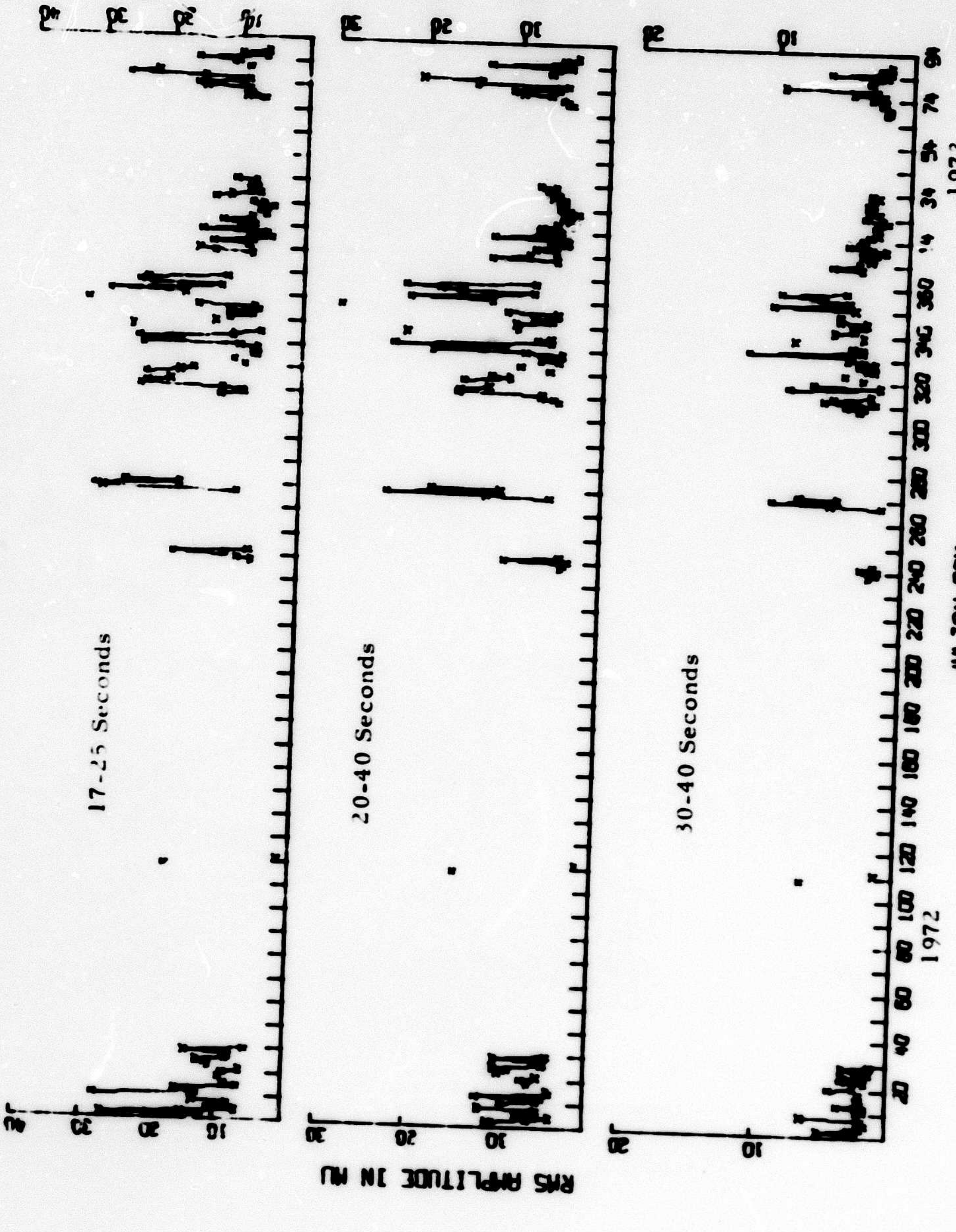

FIGURE III-2

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION CHG

SITE 3. FBK

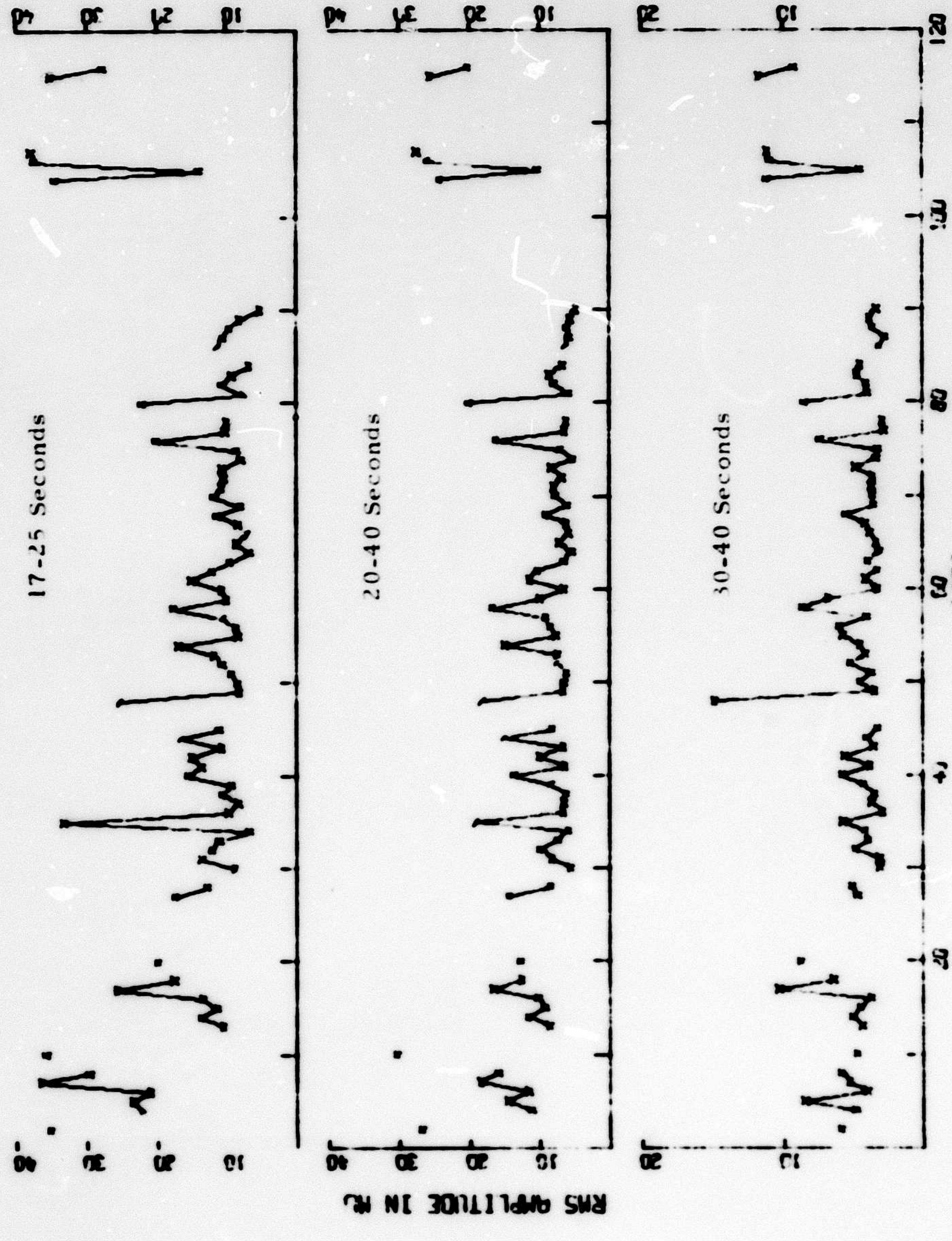

FIGURE III-3

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION FBK

SITE 4. TLO

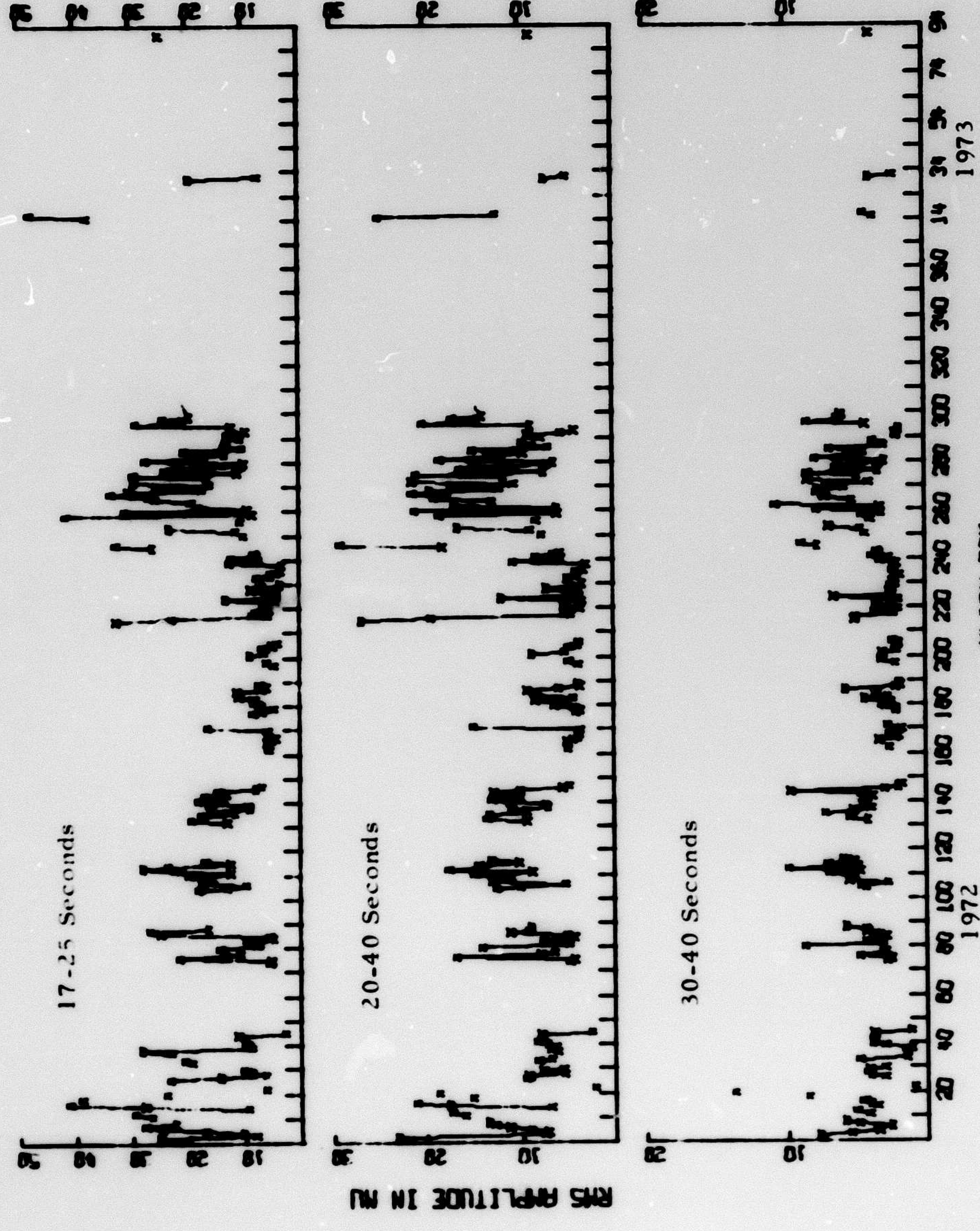

FIGURE III-4

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION TLO

SITE 5. EIL

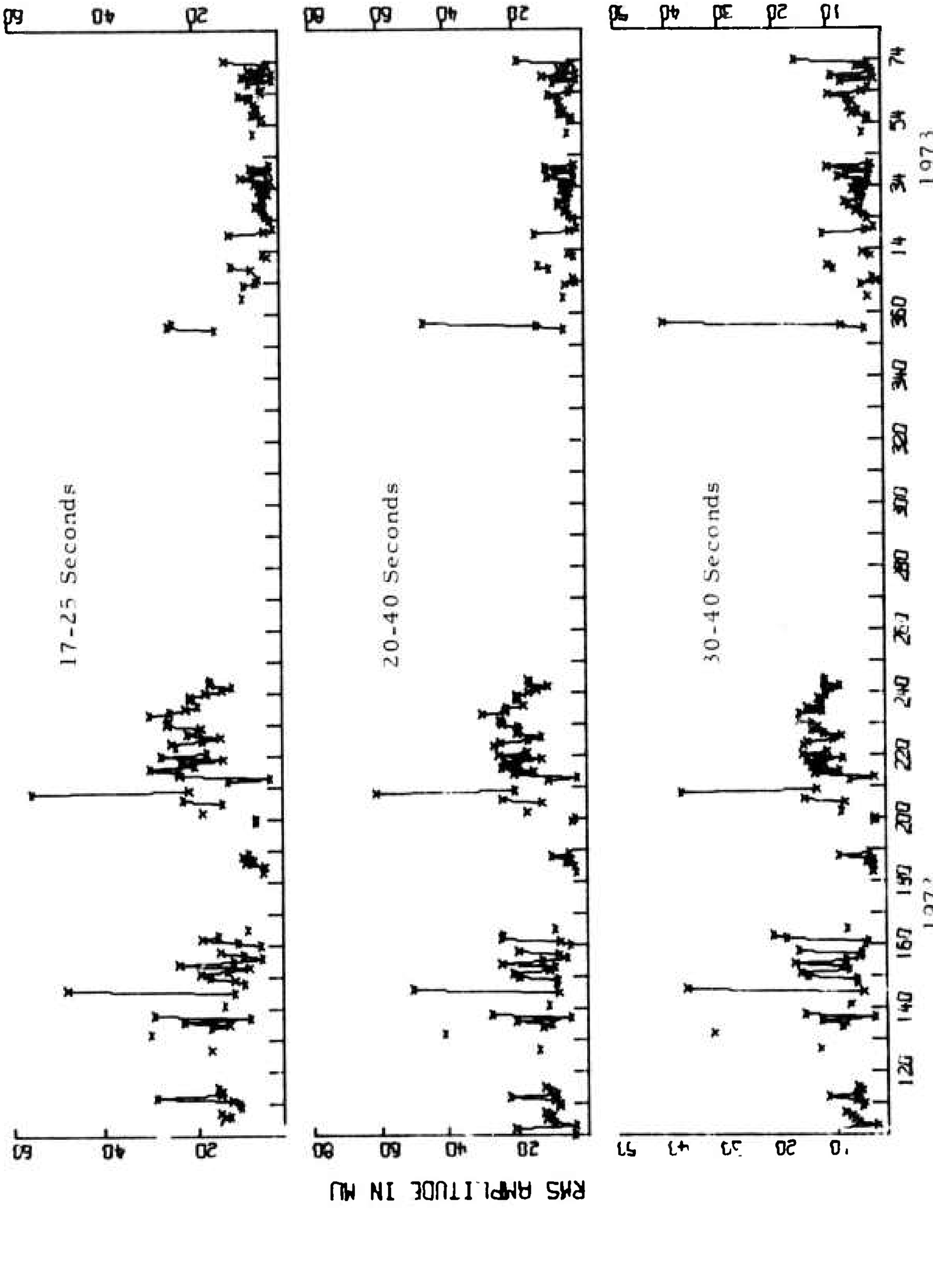

FIGURE III-5
VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION EIL

SITE 6. KON

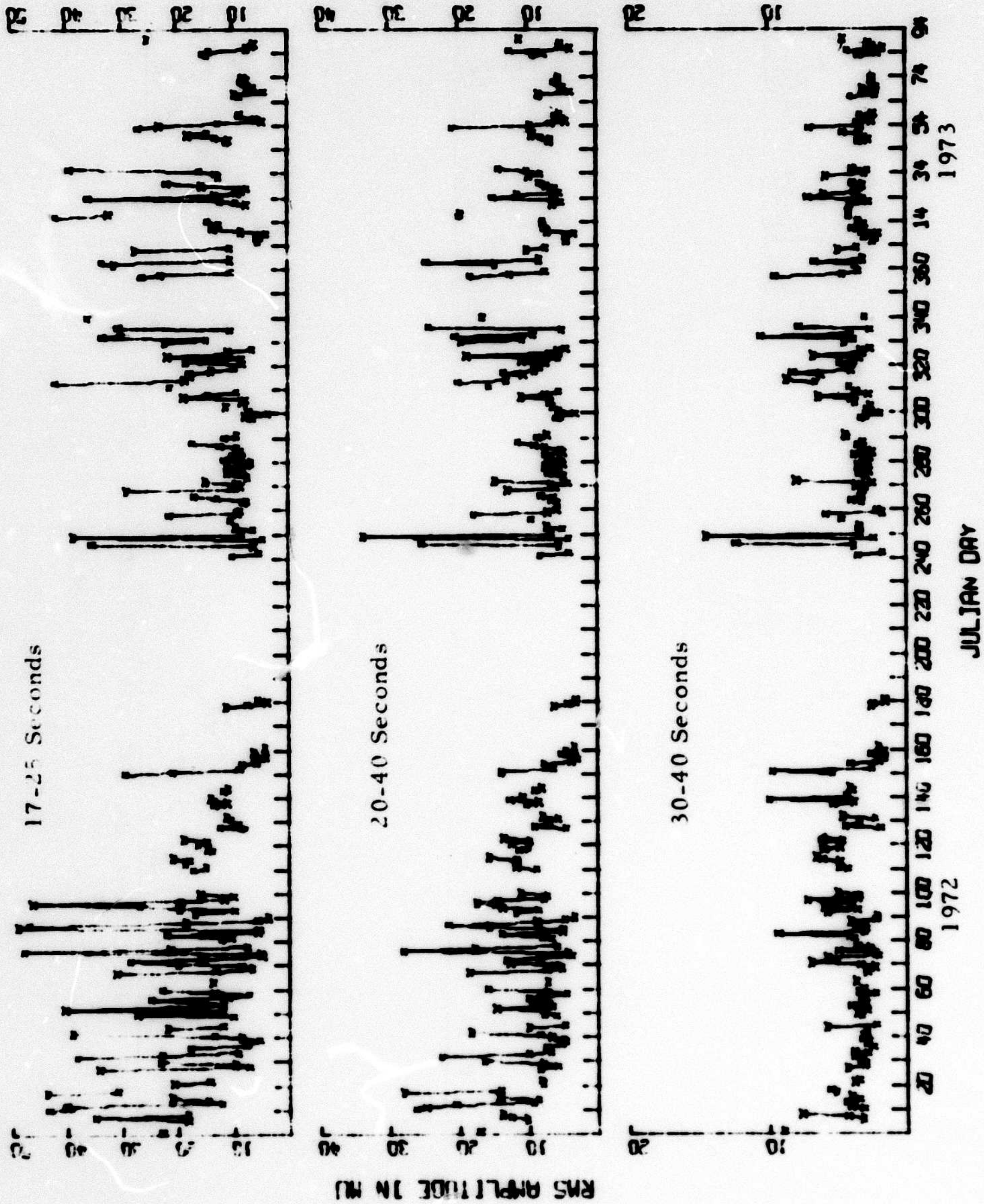

FIGURE III-6

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION KON

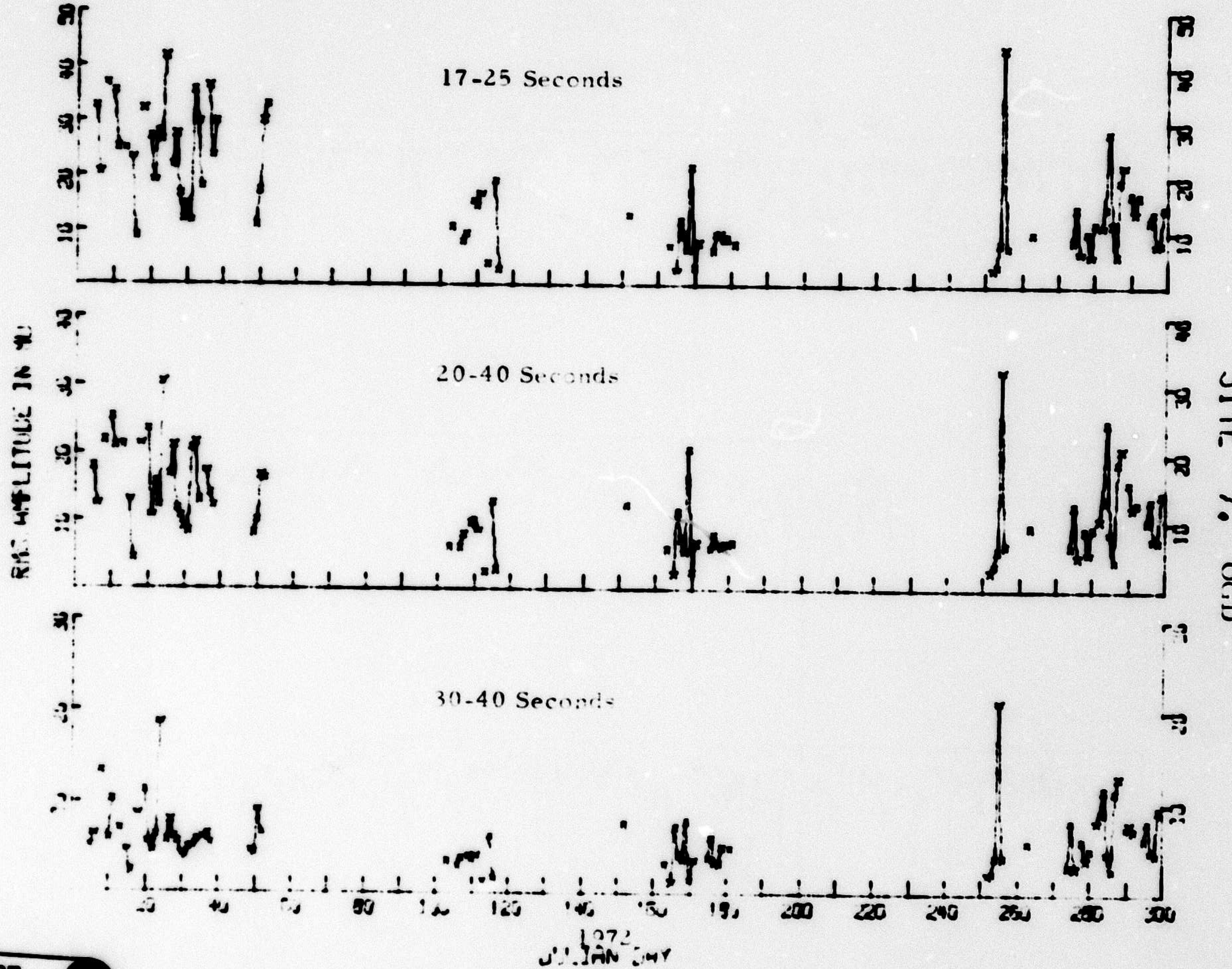

FIGURE III-7

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION OGD

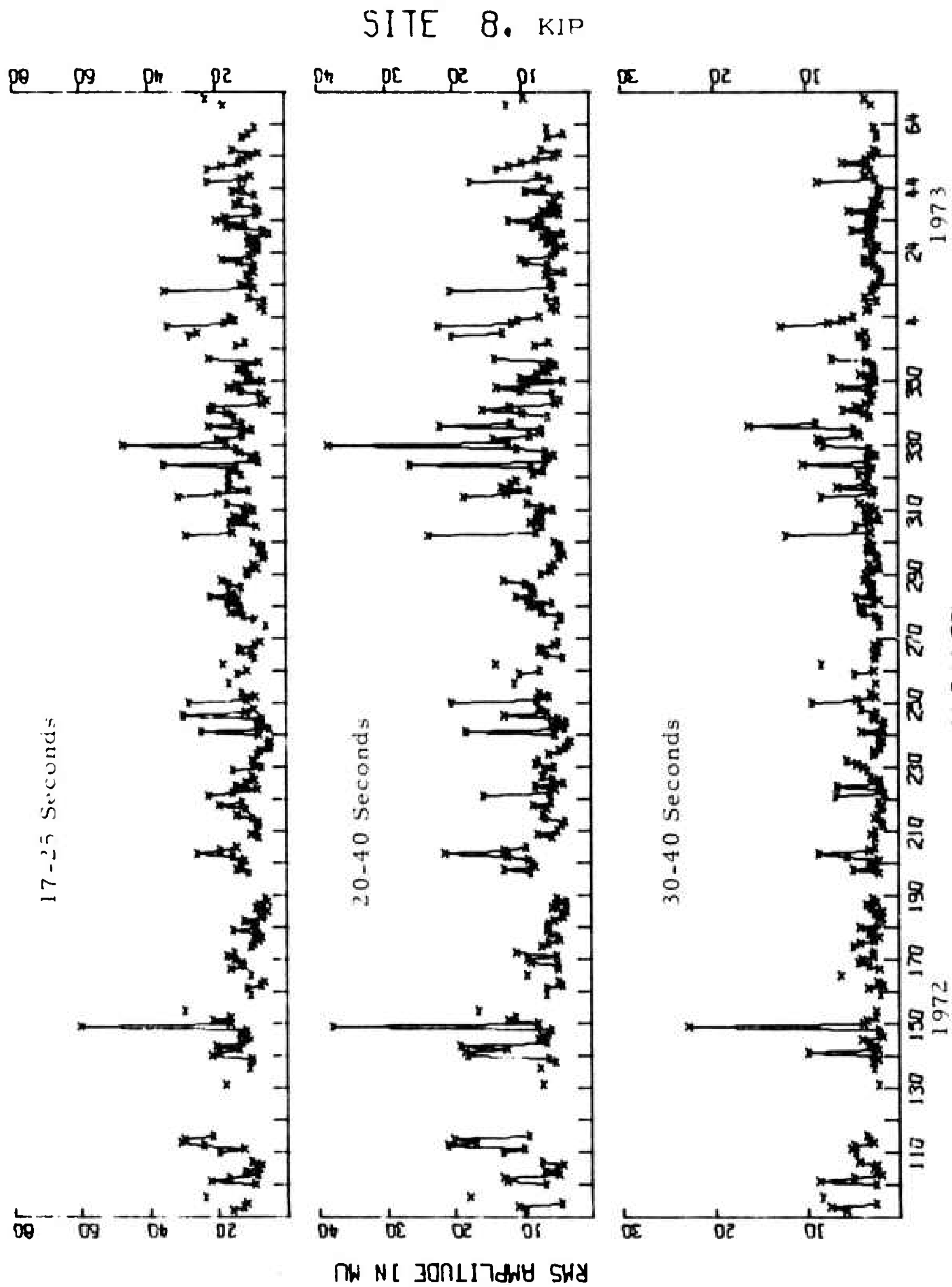

FIGURE III-8

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION KIP

SITE 9. ALQ

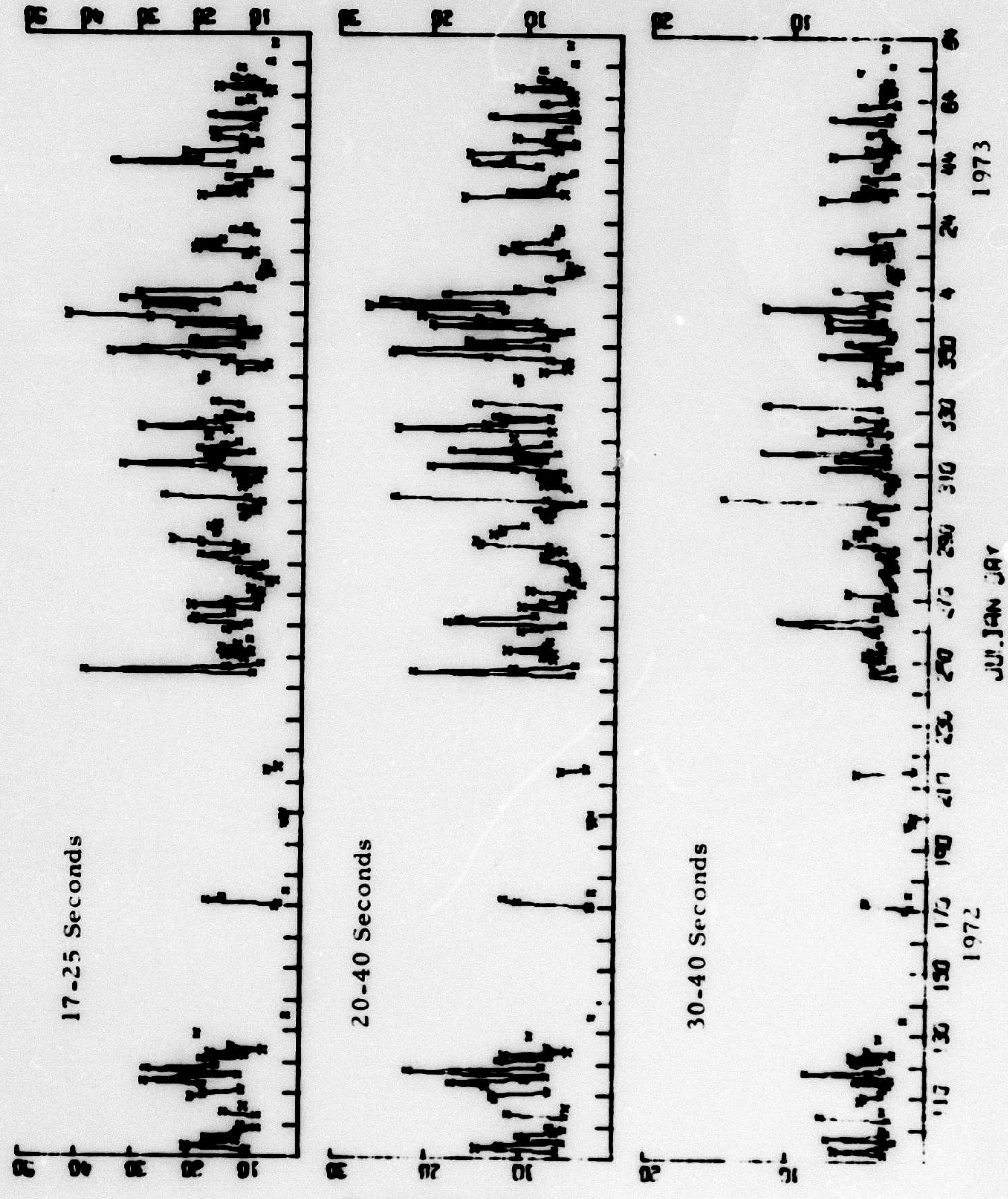

FIGURE III-

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION ALQ

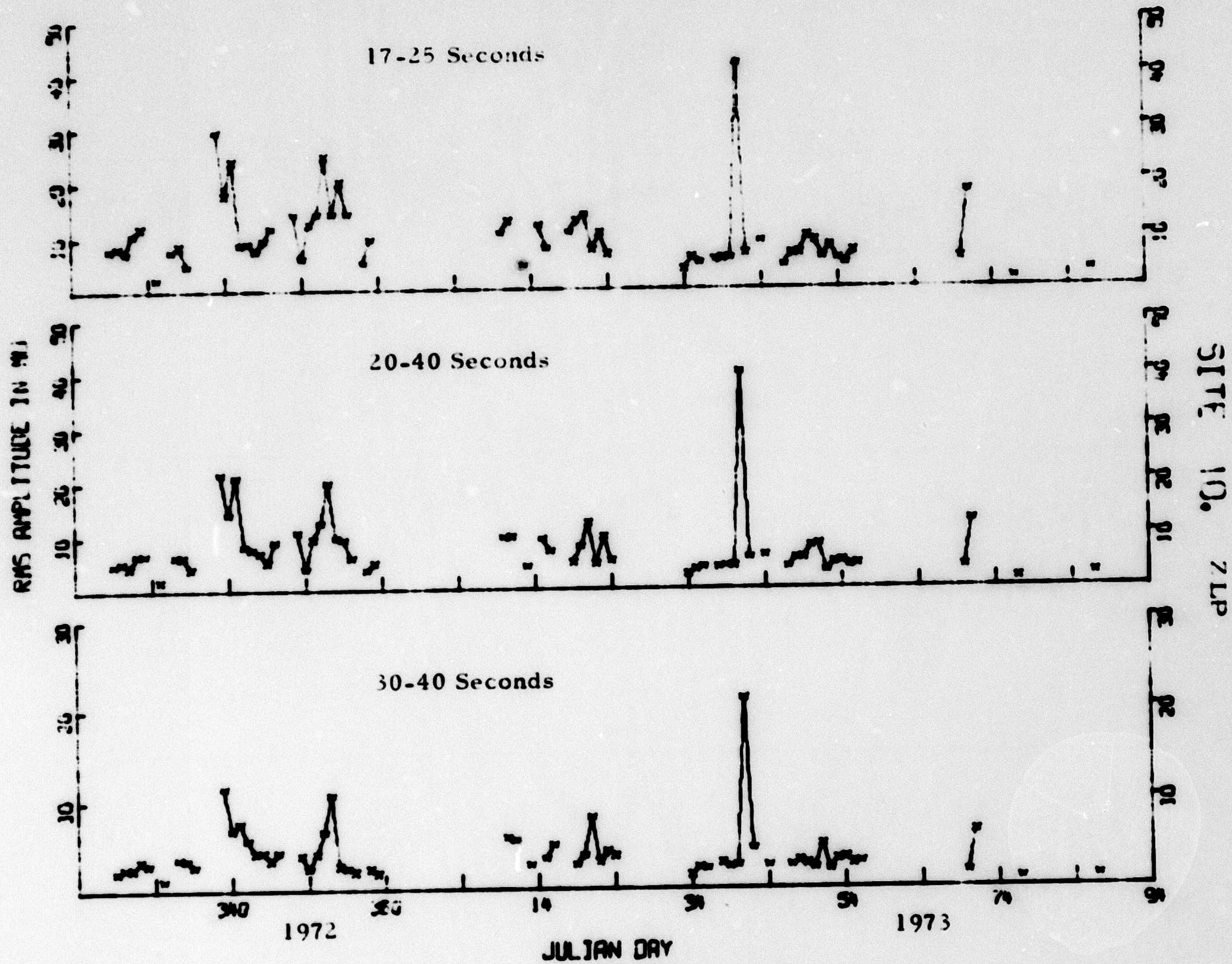

FIGURE III-10

VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION ZLP

SITE 11. MAT

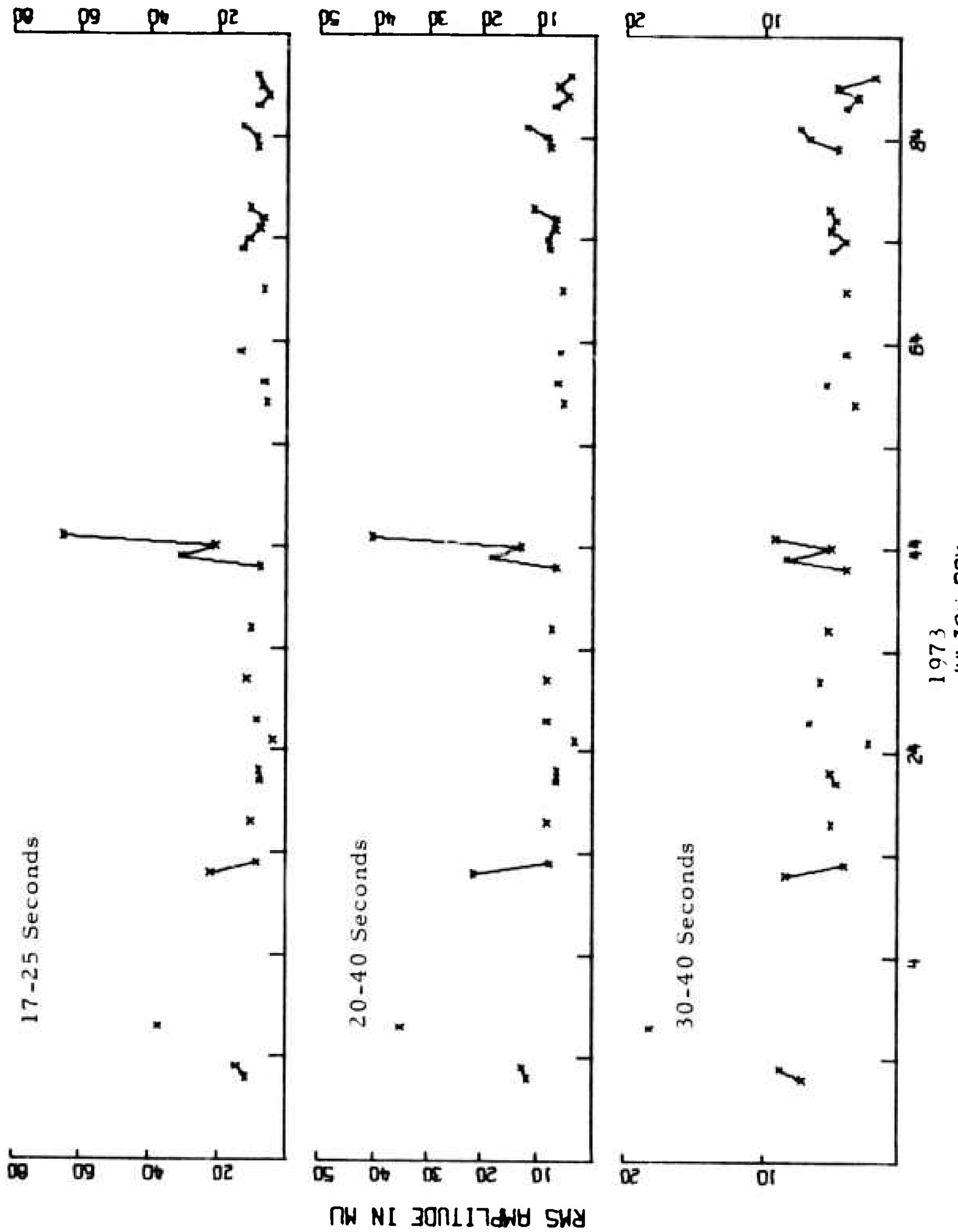

FIGURE III-11
VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION MAT

TABLE III-1

MEAN RMS AMPLITUDES AND STANDARD DEVIATIONS OF VERTICAL COMPONENT NOISE AT VERY LONG PERIOD EXPERIMENT STATIONS

Station	17-25 Seconds Period Band	20-40 Seconds Period Band	30-40 Seconds Period Band
CTA	18.8 ± 9.3 mμ	10.8 ± 6.6 mμ	3.8 ± 2.8 mμ
CHG	12.6 ± 6.5 mμ	8.7 ± 5.2 mμ	3.6 ± 2.0 mμ
FBK	15.1 ± 8.7 mμ	10.9 ± 6.0 mμ	5.1 ± 2.4 mμ
TLO	14.7 ± 9.2 mμ	11.8 ± 5.6 mμ	4.3 ± 2.1 mμ
EIL	12.8 ± 9.3 mμ	12.8 ± 9.8 mμ	8.1 ± 6.7 mμ
KON	15.4 ± 10.2 mμ	9.6 ± 5.4 mμ	4.0 ± 1.9 mμ
OGD	16.6 ± 10.1 mμ	11.9 ± 6.6 mμ	5.9 ± 3.4 mμ
KIP	13.8 ± 7.0 mμ	8.7 ± 5.0 mμ	3.7 ± 2.4 mμ
ALQ	13.7 ± 6.8 mμ	9.2 ± 4.9 mμ	4.0 ± 3.0 mμ
ZLP	10.2 ± 6.9 mμ	7.8 ± 6.0 mμ	4.0 ± 3.0 mμ
MAT	13.5 ± 11.8 mμ	10.5 ± 8.1 mμ	5.6 ± 2.9 mμ

The small quantity and sparse (noncontinuous) distribution of the vertical component noise data severely limited the determination of long-term noise trends. However, monthly averages of the RMS amplitudes for each VLPE station are displayed in Figures III-12 through III-22. Figure III-17 for station KON illustrates seasonal trends similar to those reported by Laun et al., (1973). Laun et al., (1973) stated that the NORSAR noise level in the 20-40 seconds period band reached a higher level during October through January than during the rest of the year, and these fluctuations appeared to correlate with varying weather conditions in the North Atlantic Ocean. Data for stations TLO, KIP, and ALQ questionably suggest lower RMS amplitudes during the summer months. Nothing conclusive can be stated about the long-term noise level behavior of stations CTA, CHG, FBK, EIL, OGD, MAT, and ZLP.

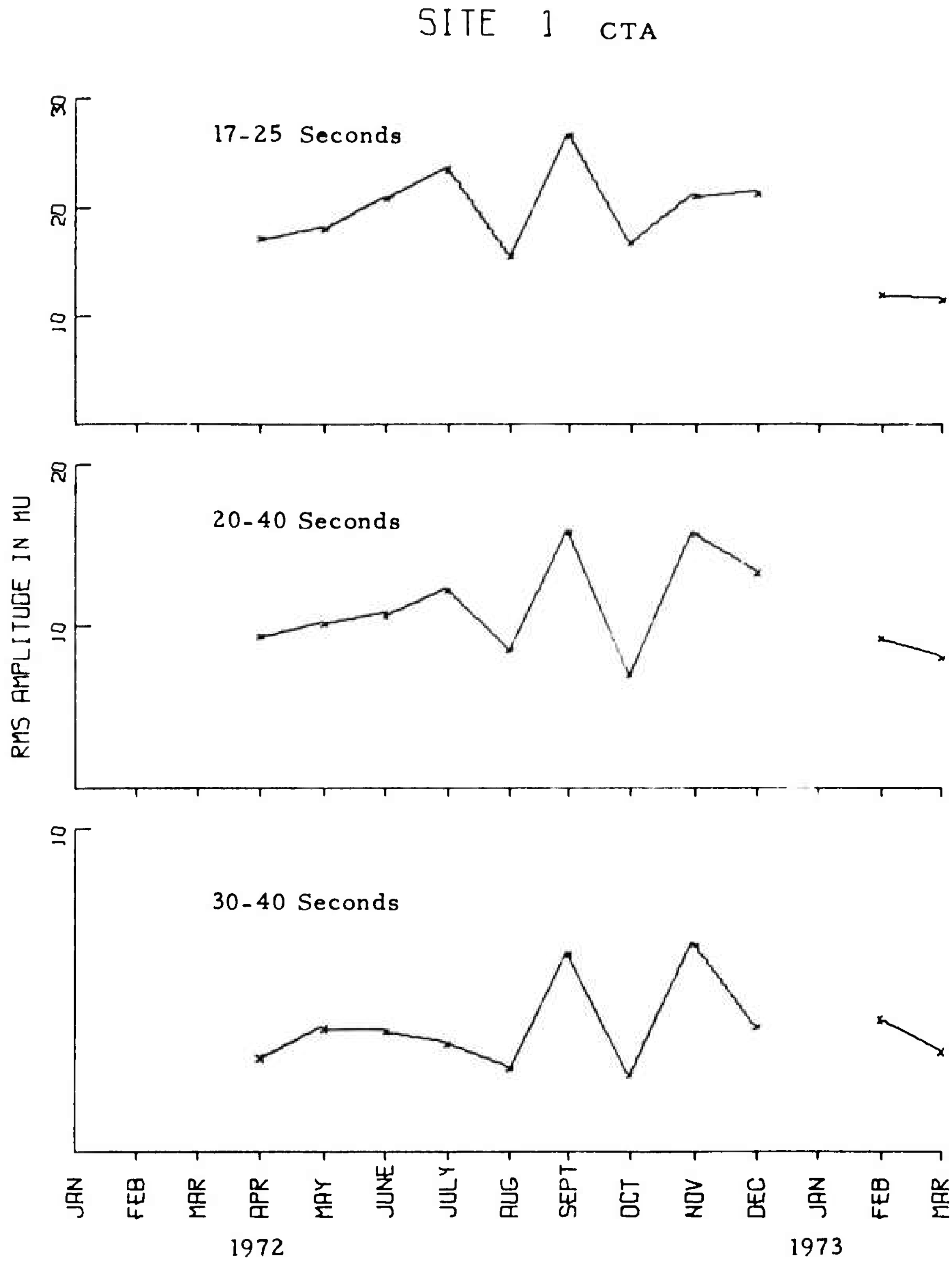

FIGURE III - 12

AVERAGE MONTHLY VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION CTA

SITE 2 CHG

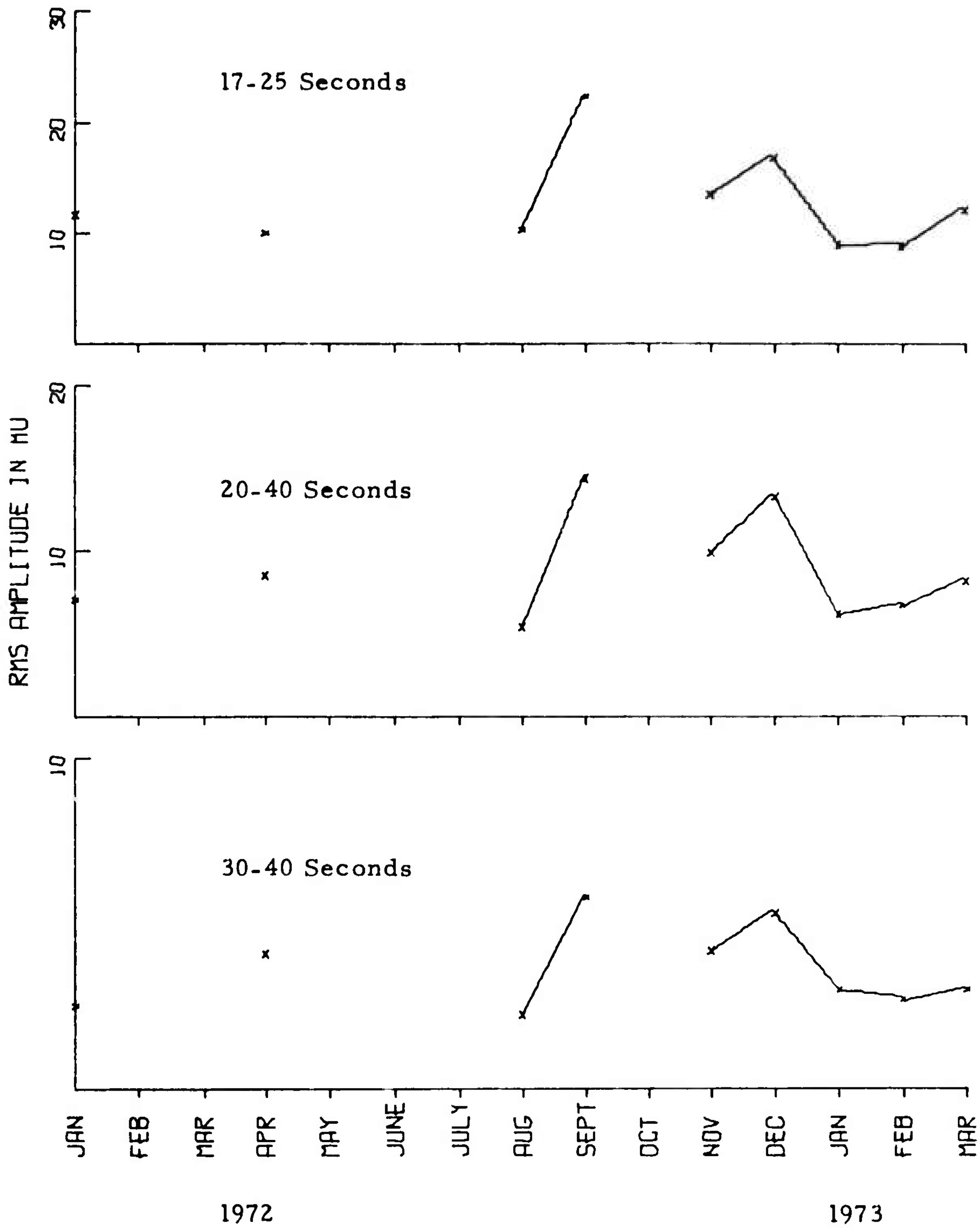

FIGURE III-13

AVERAGE MONTHLY VERTICAL RMS NOISE
AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION CHG

SITE 3 FBK

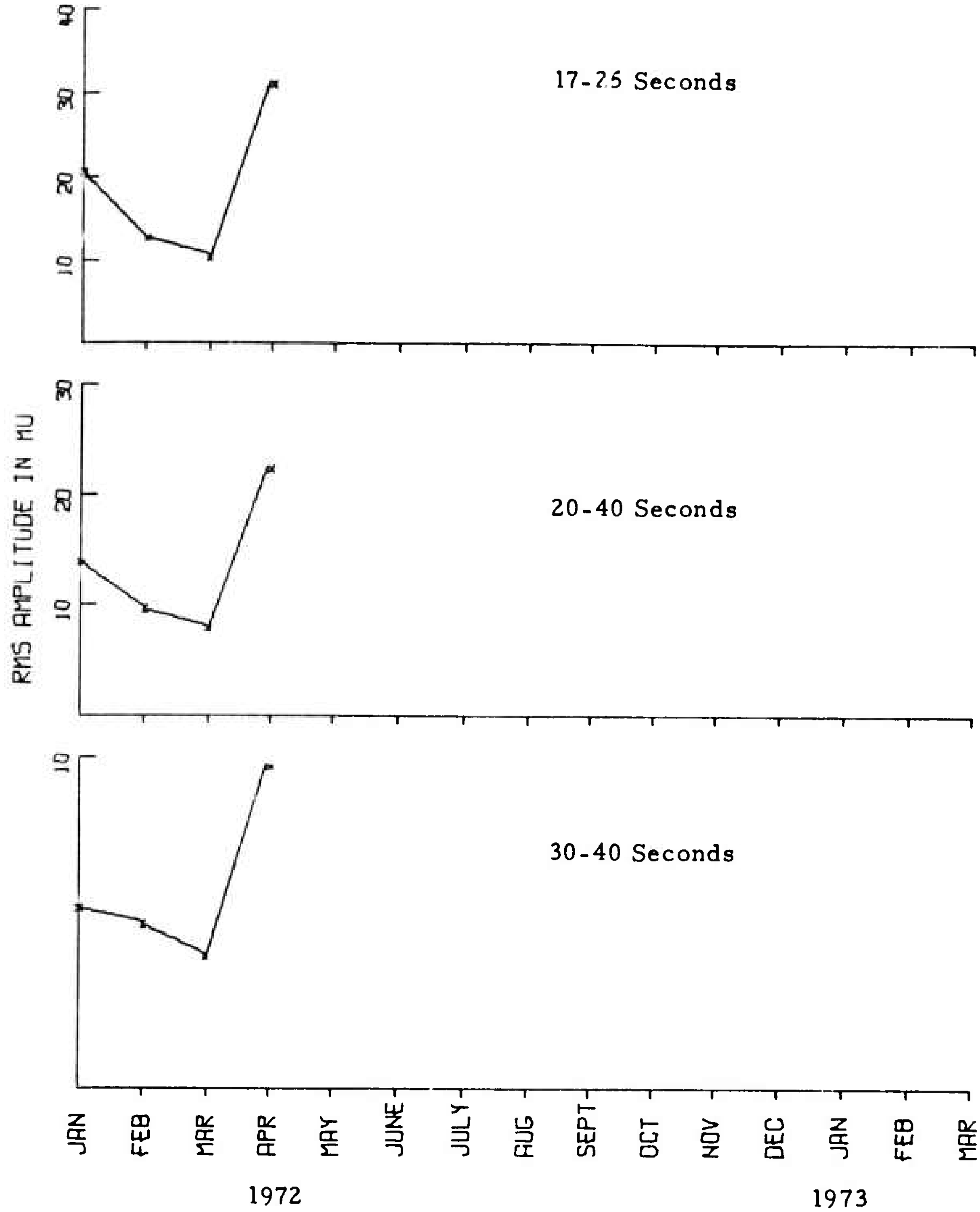

FIGURE III - 14

AVERAGE MONTHLY VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION FBK

SITE 4 TLO

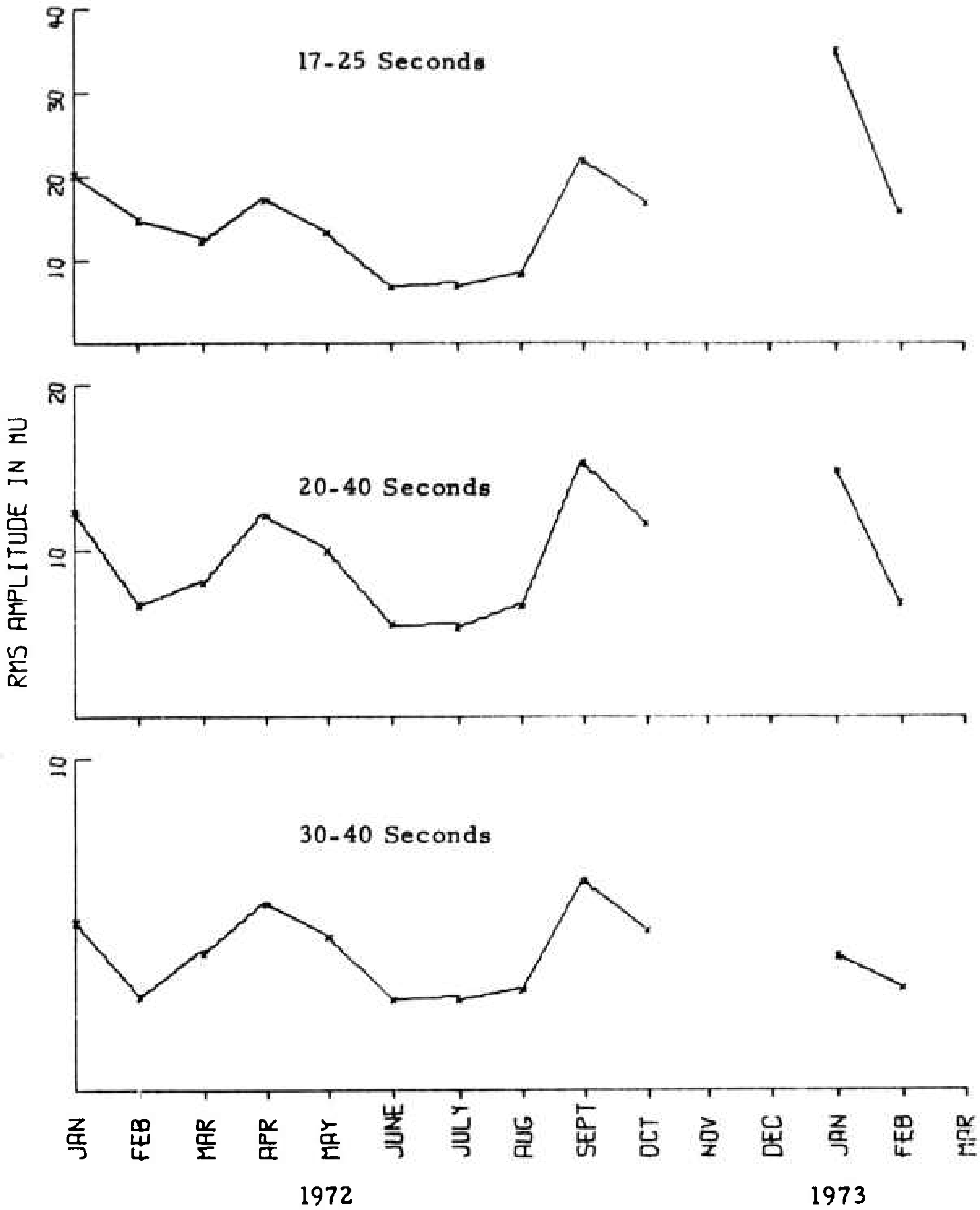

FIGURE III - 15

AVERAGE MONTHLY VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION TLO

SITE 5 EIL

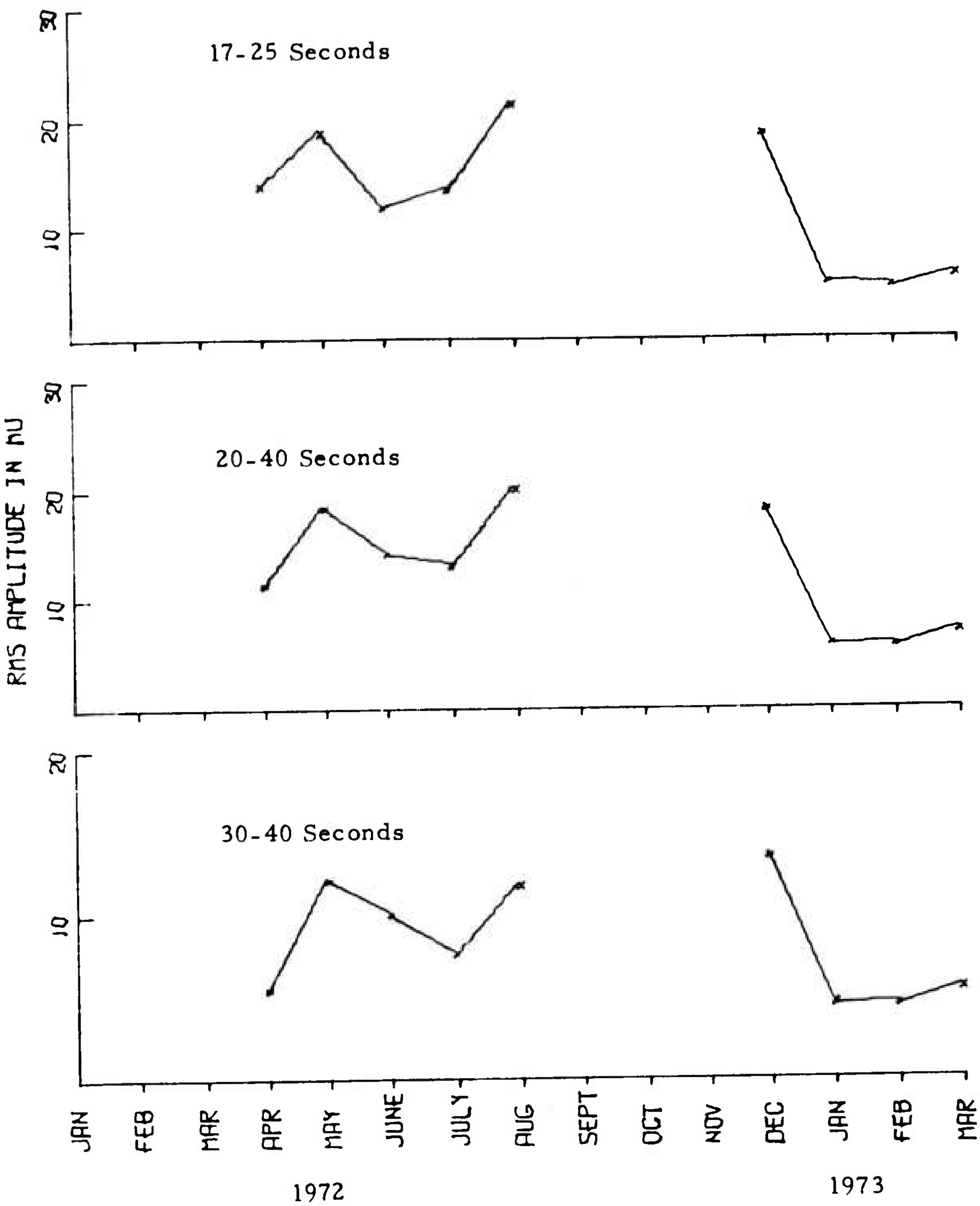

FIGURE III - 16

AVERAGE MONTHLY VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION EIL

SITE 6 KON

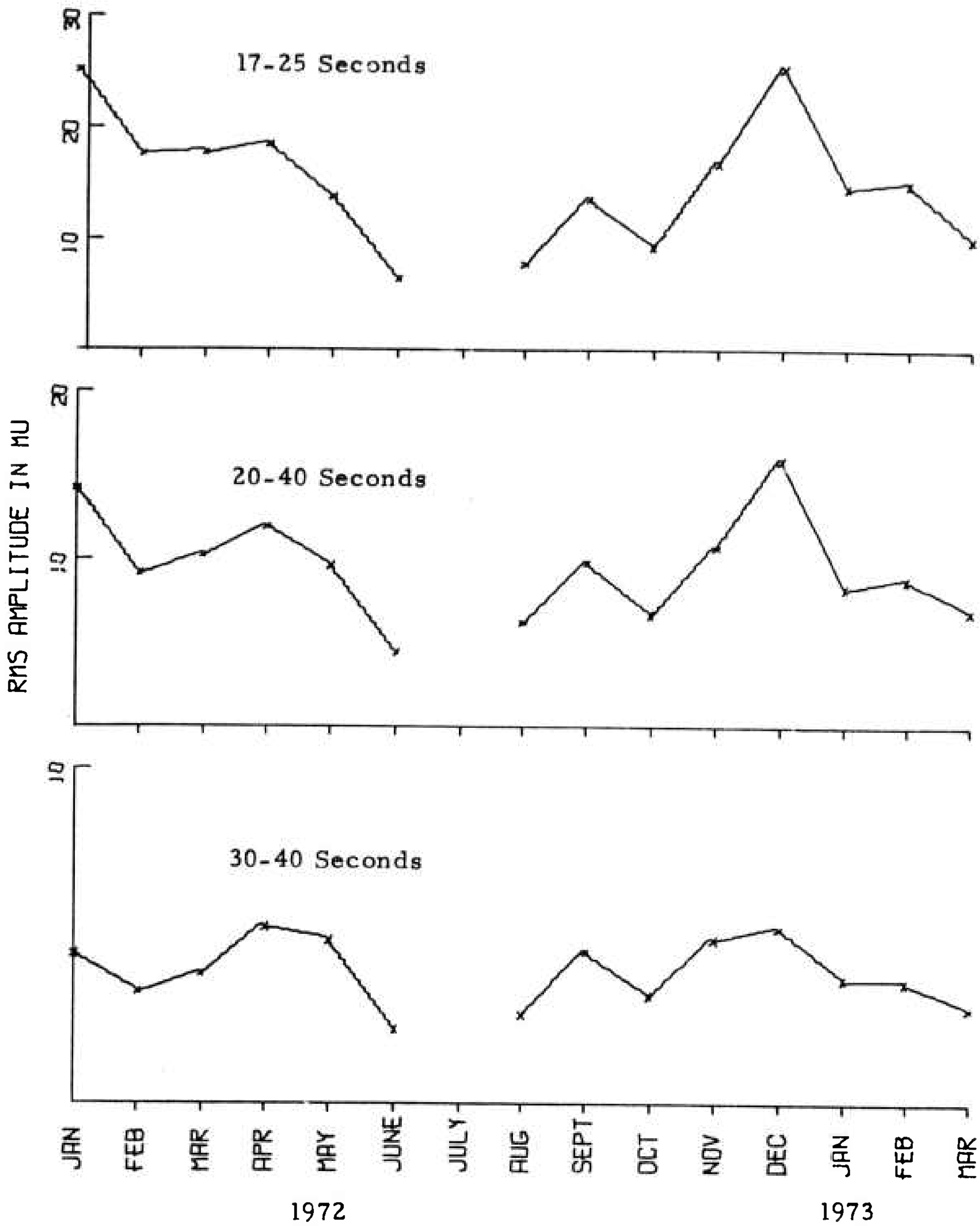

FIGURE III-17

AVERAGE MONTHLY VERTICAL RMS NOISE
AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION KON

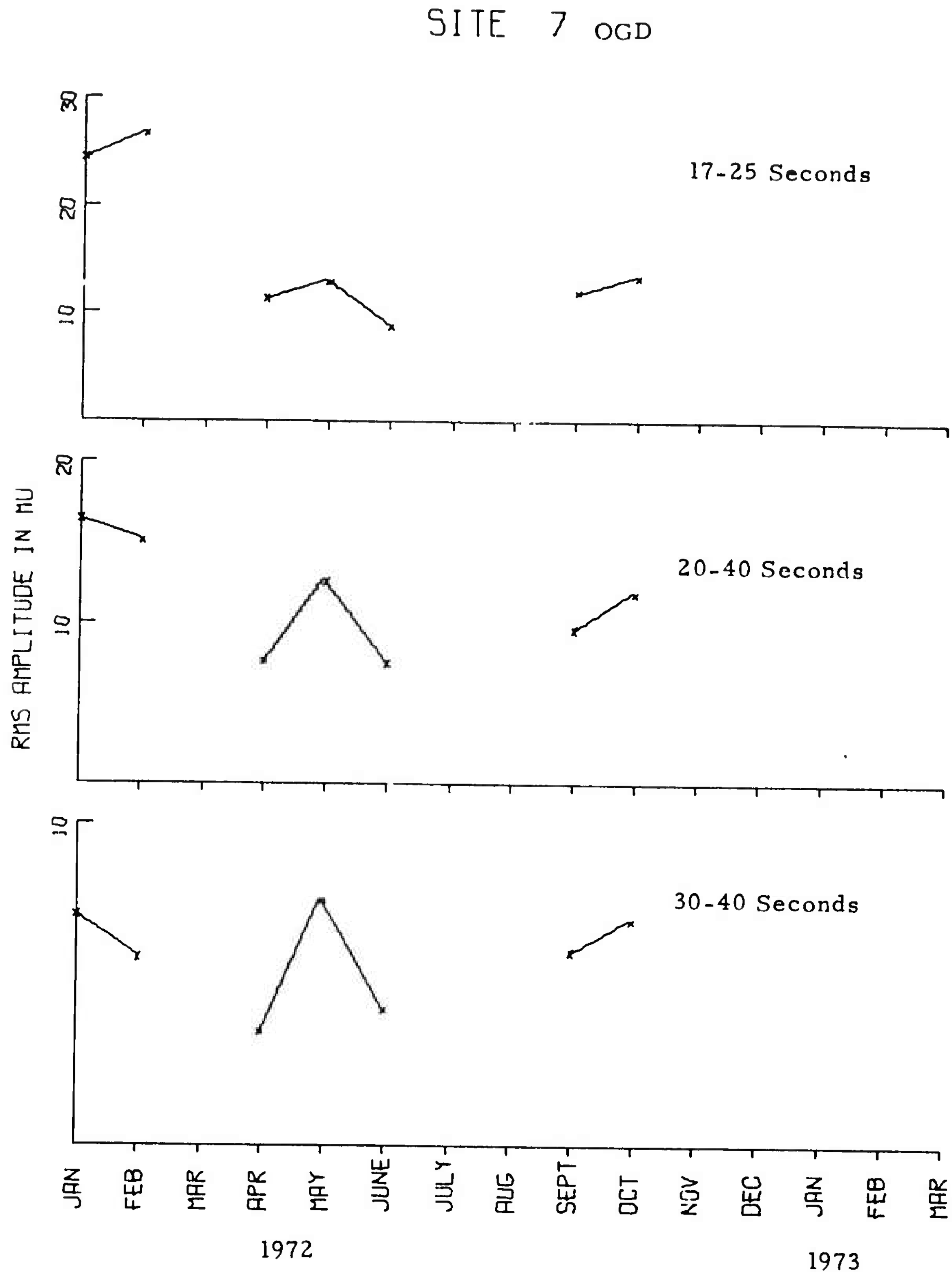

FIGURE III - 18

AVERAGE MONTHLY VERTICAL RMS NOISE
AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION OGD

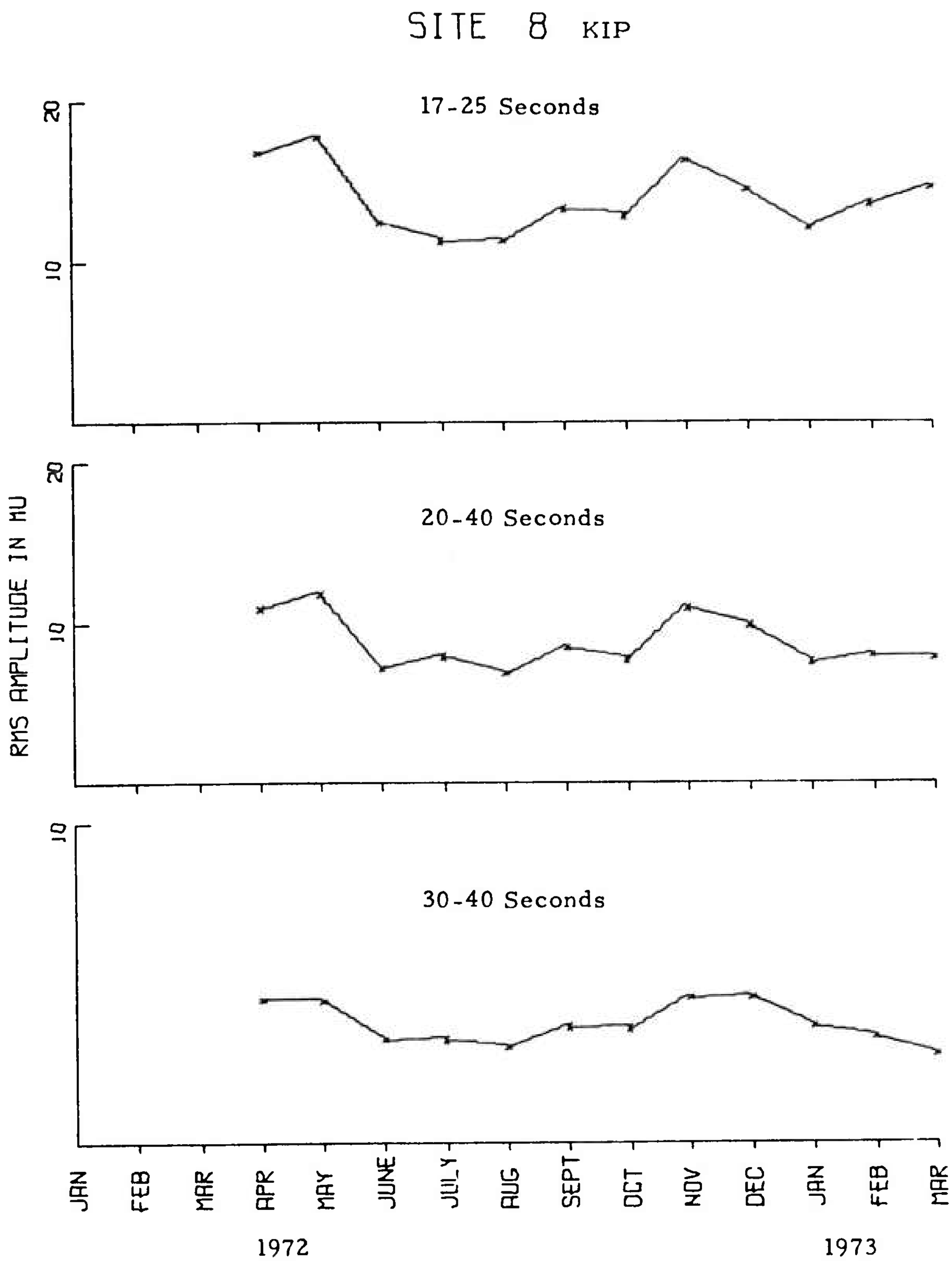

FIGURE III - 19

AVERAGE MONTHLY VERTICAL RMS NOISE
AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION KIP

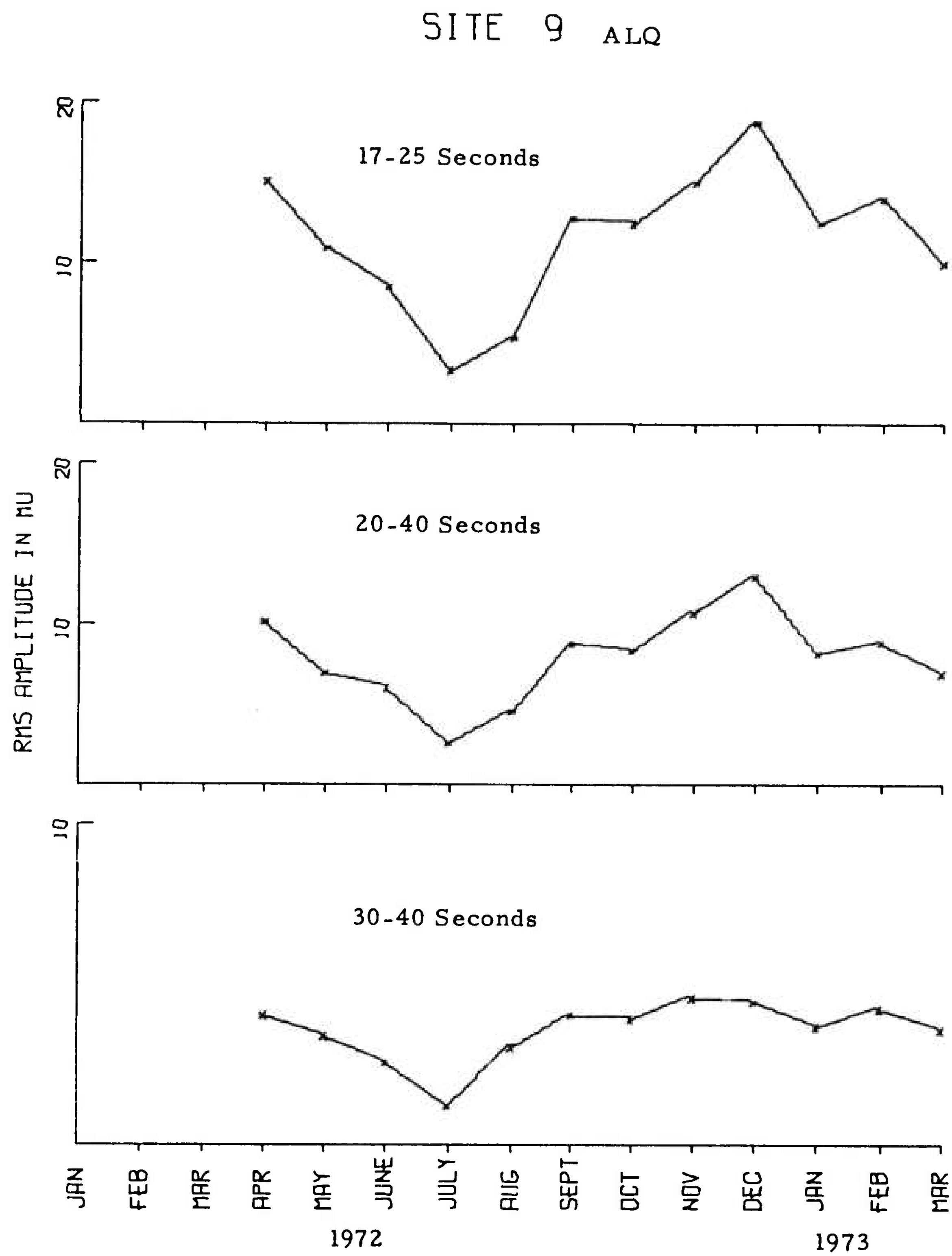

FIGURE III - 20

AVERAGE MONTHLY VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION ALQ

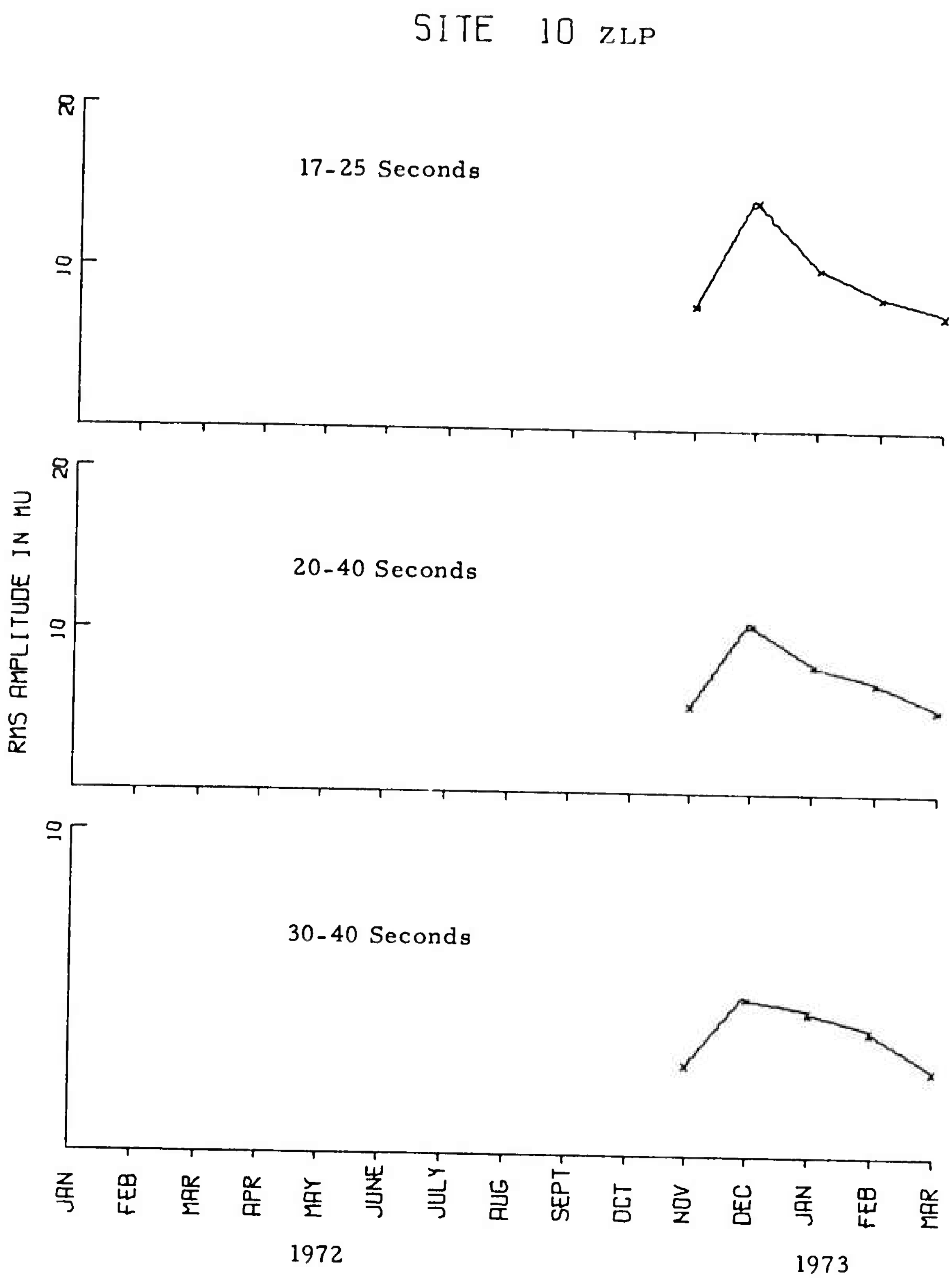

FIGURE III - 21

AVERAGE MONTHLY VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION ZLP

SITE 11 MAT

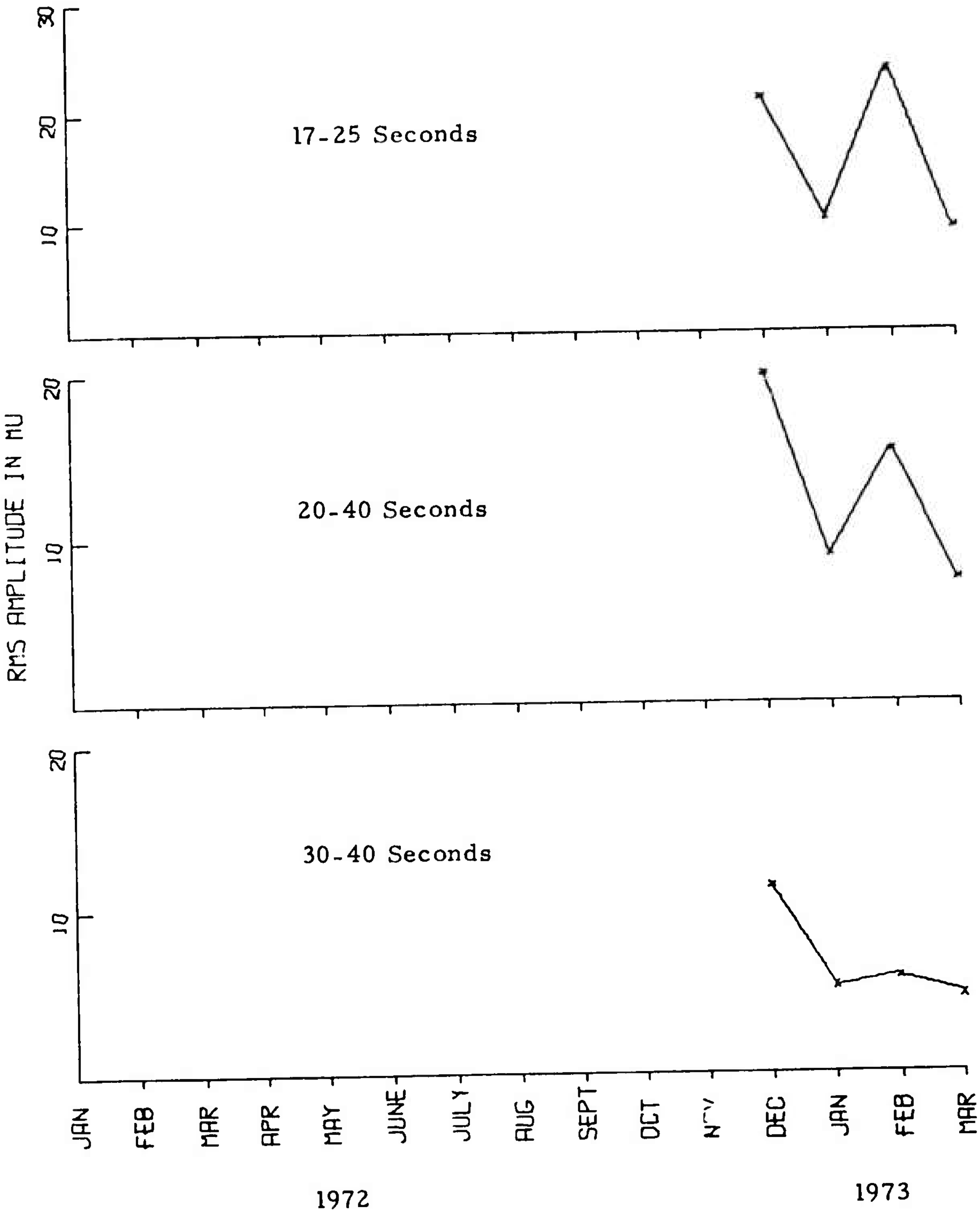

FIGURE III - 22

AVERAGE MONTHLY VERTICAL RMS NOISE AMPLITUDES AT VERY LONG PERIOD EXPERIMENT STATION MAT

SECTION IV
THREE COMPONENT NOISE ANALYSIS

A. INTRODUCTION

Extension of the noise analysis to include the horizontal components as well as the vertical component was necessary to accurately delineate the noise characteristics at VLPE stations since the horizontal components illustrate the presence of any noise directionality. RMS amplitude spectra were calculated to yield amplitude and frequency characteristics of earth noise, and two-component coherence to determine power interrelationships between the different components.

B. THREE COMPONENT NOISE SPECTRA

The RMS amplitudes of the 846 simultaneous vertical and horizontal components noise samples were calculated as described in Sections II and III for the vertical component noise samples. These RMS amplitudes from 13.5 to 62.5 seconds period were averaged over all available samples to produce the three component noise spectra shown in Figures IV-1 through IV-11. Since these spectra are year-long averages, short-term effects are not visible. The vertical lines centered around each data point on the log RMS amplitude versus period plots represent the standard deviations of the spectra values (i.e., variability of the RMS amplitudes). These log plots were displayed for the illustration of the RMS amplitude variabilities and were obtained by averaging the log values of all the available RMS amplitudes. Also, the frequency of occurrence of RMS amplitudes approximate a log-normal distribution (Alsup and Becker, 1973b).

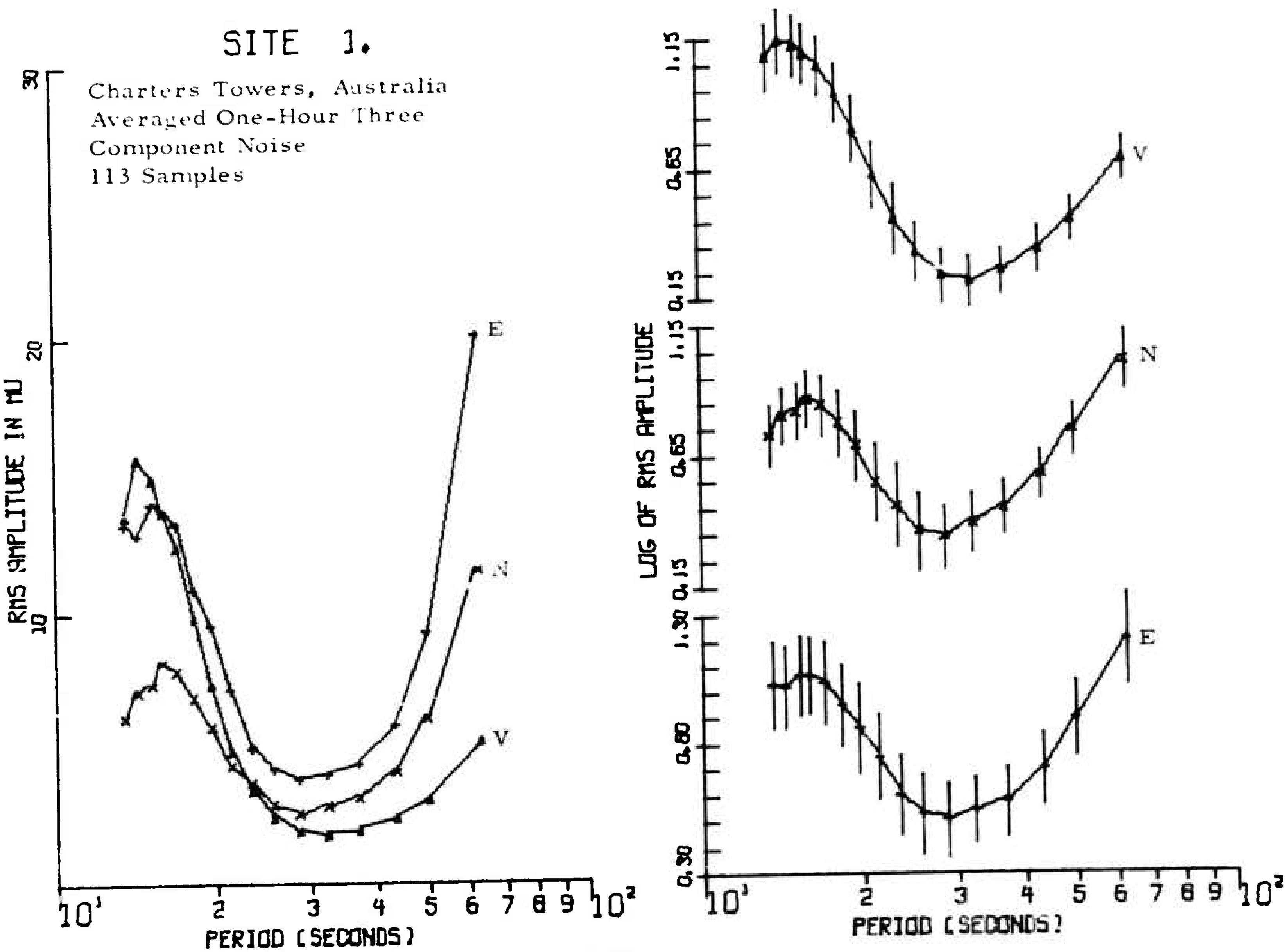

FIGURE IV-1

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION CTA

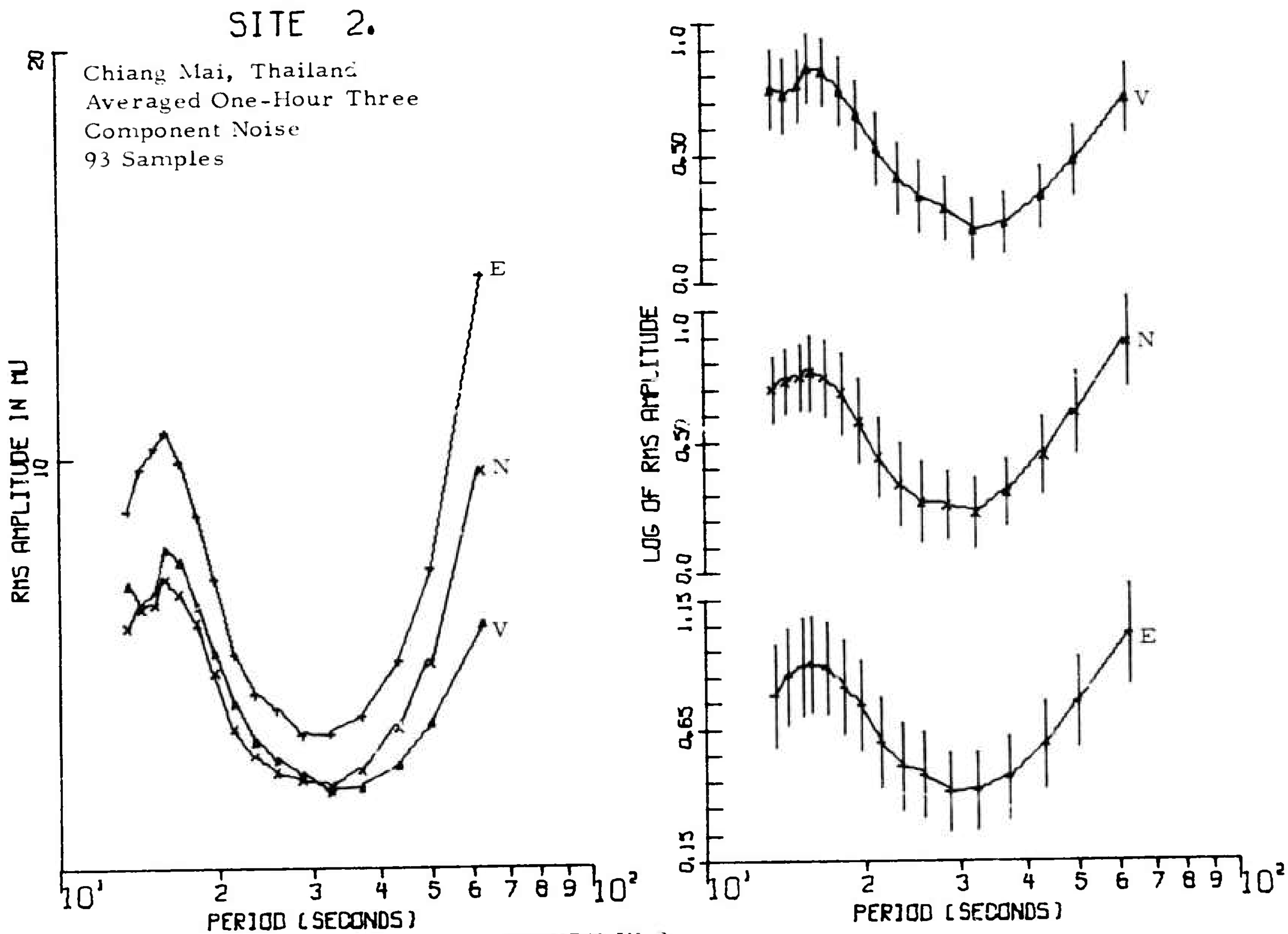

FIGURE IV-2

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION CHG

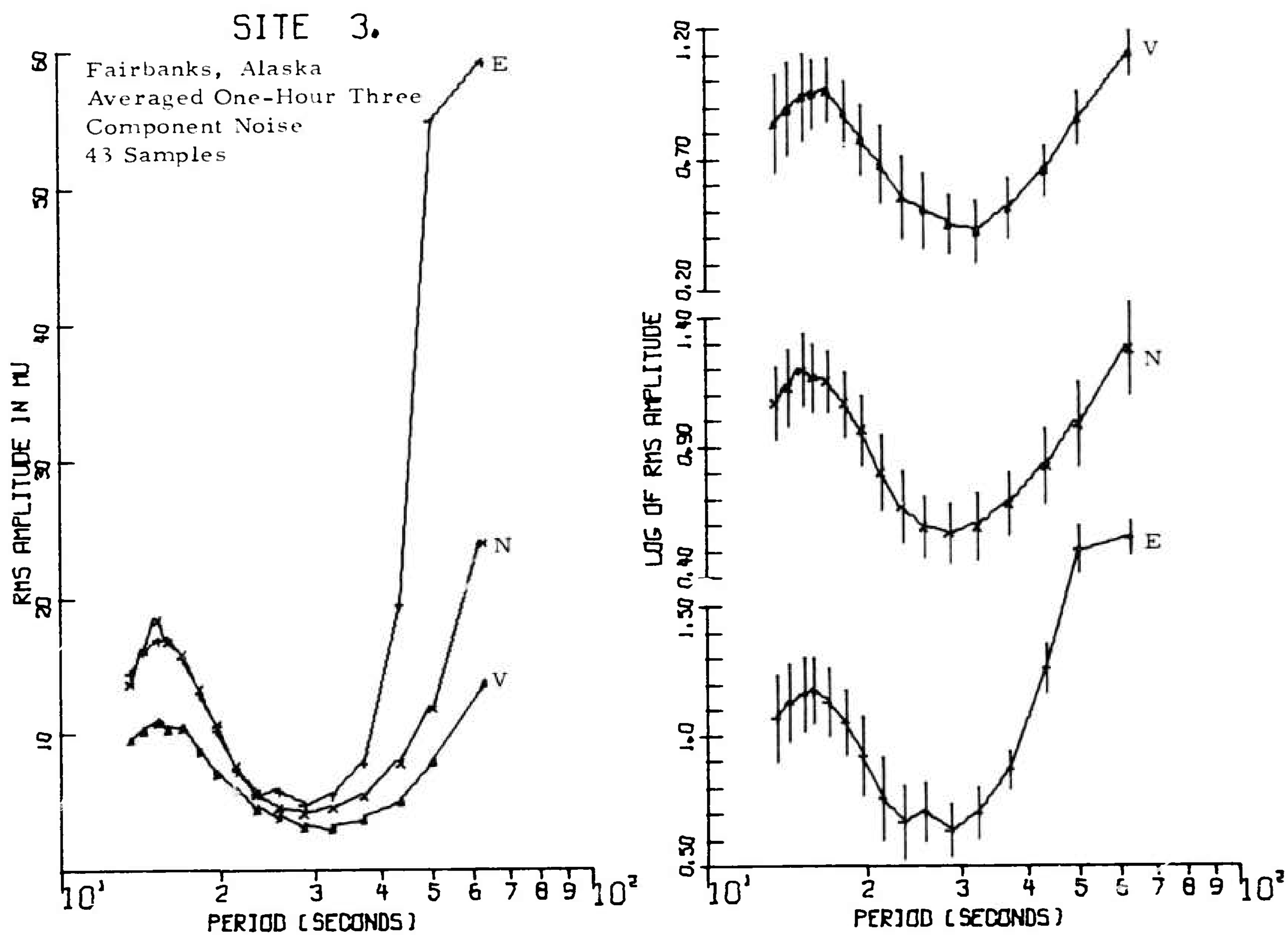

FIGURE IV-3

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION FBK

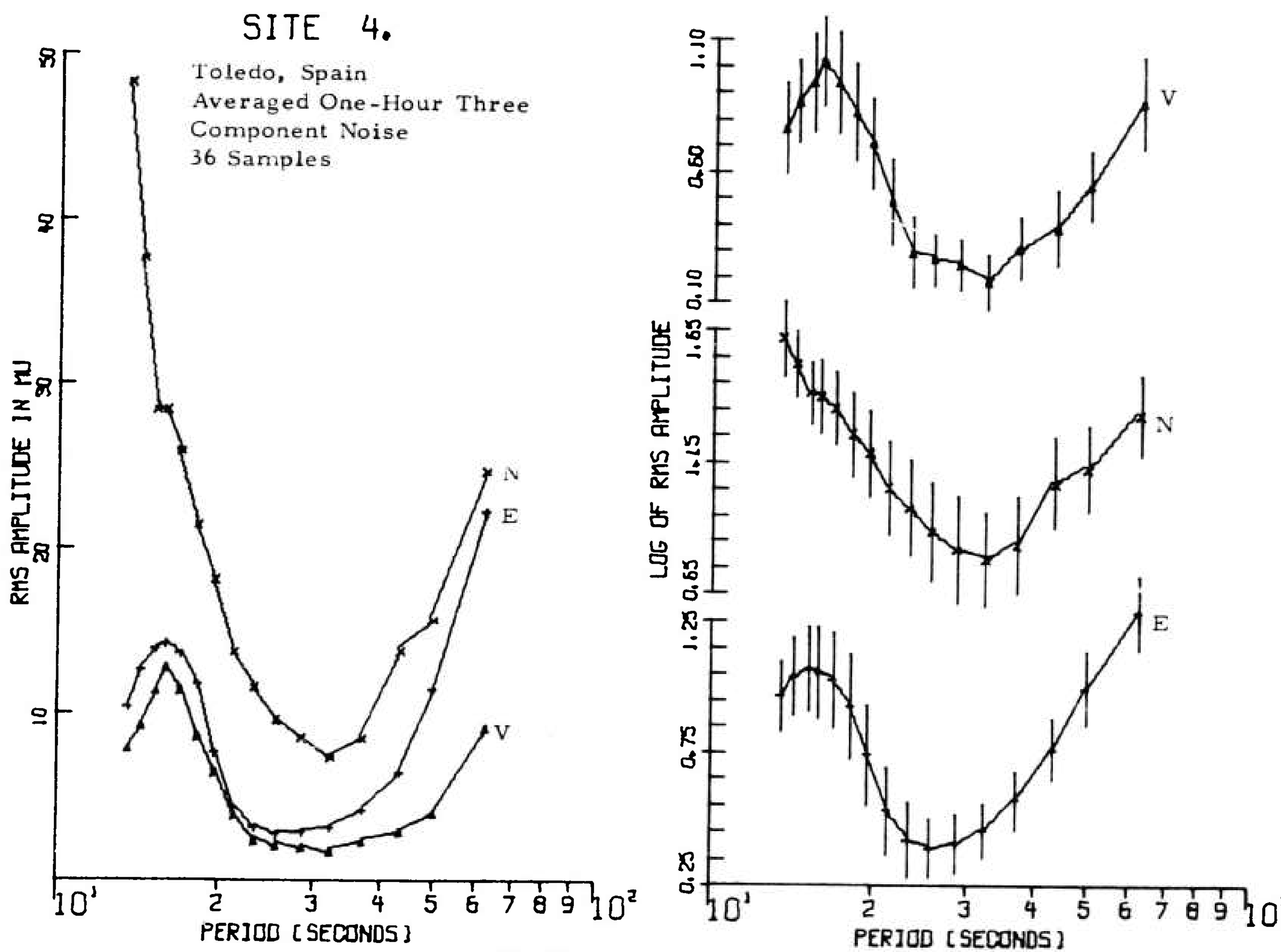

FIGURE IV-4

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION TLO

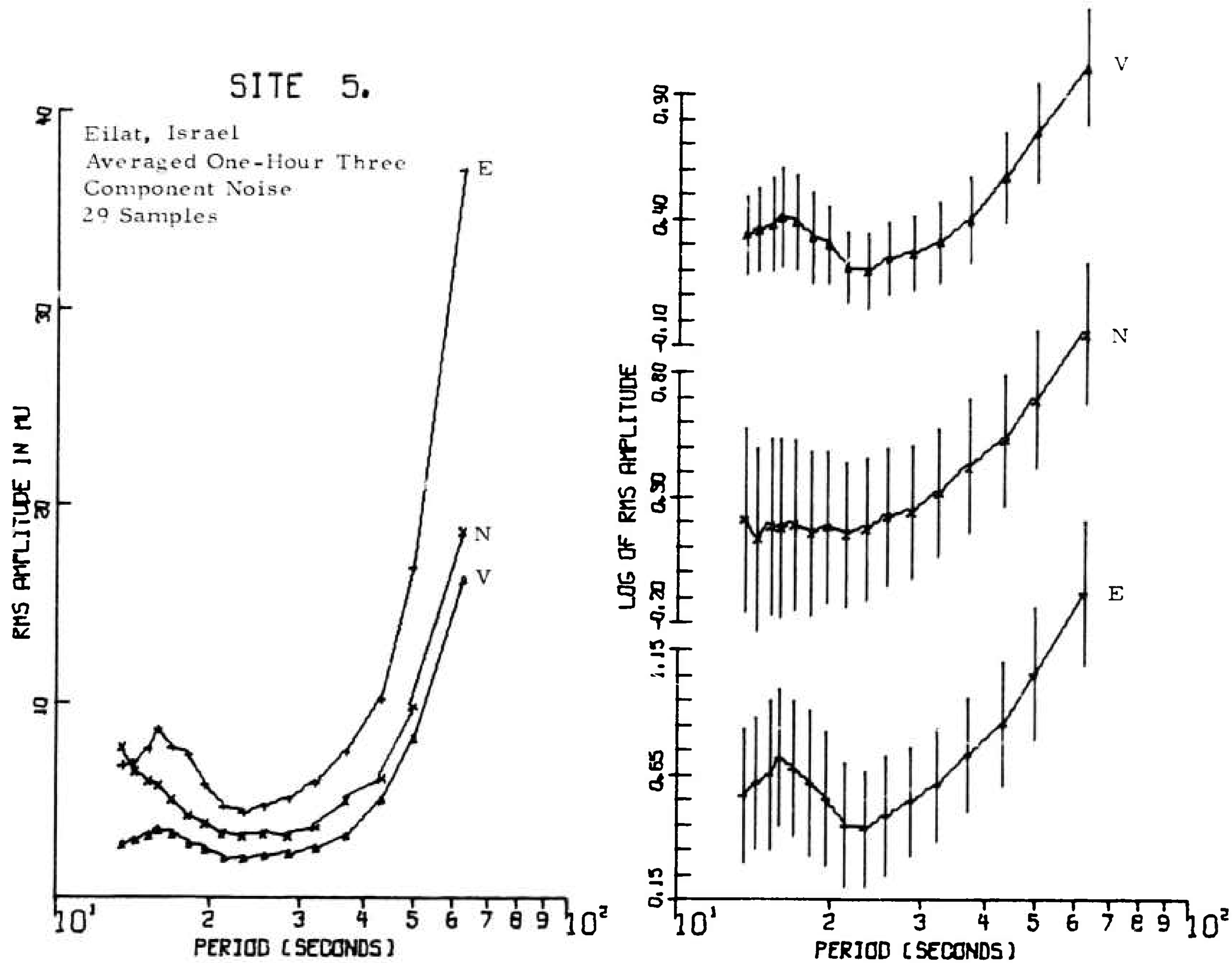

FIGURE IV-5

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION EIL

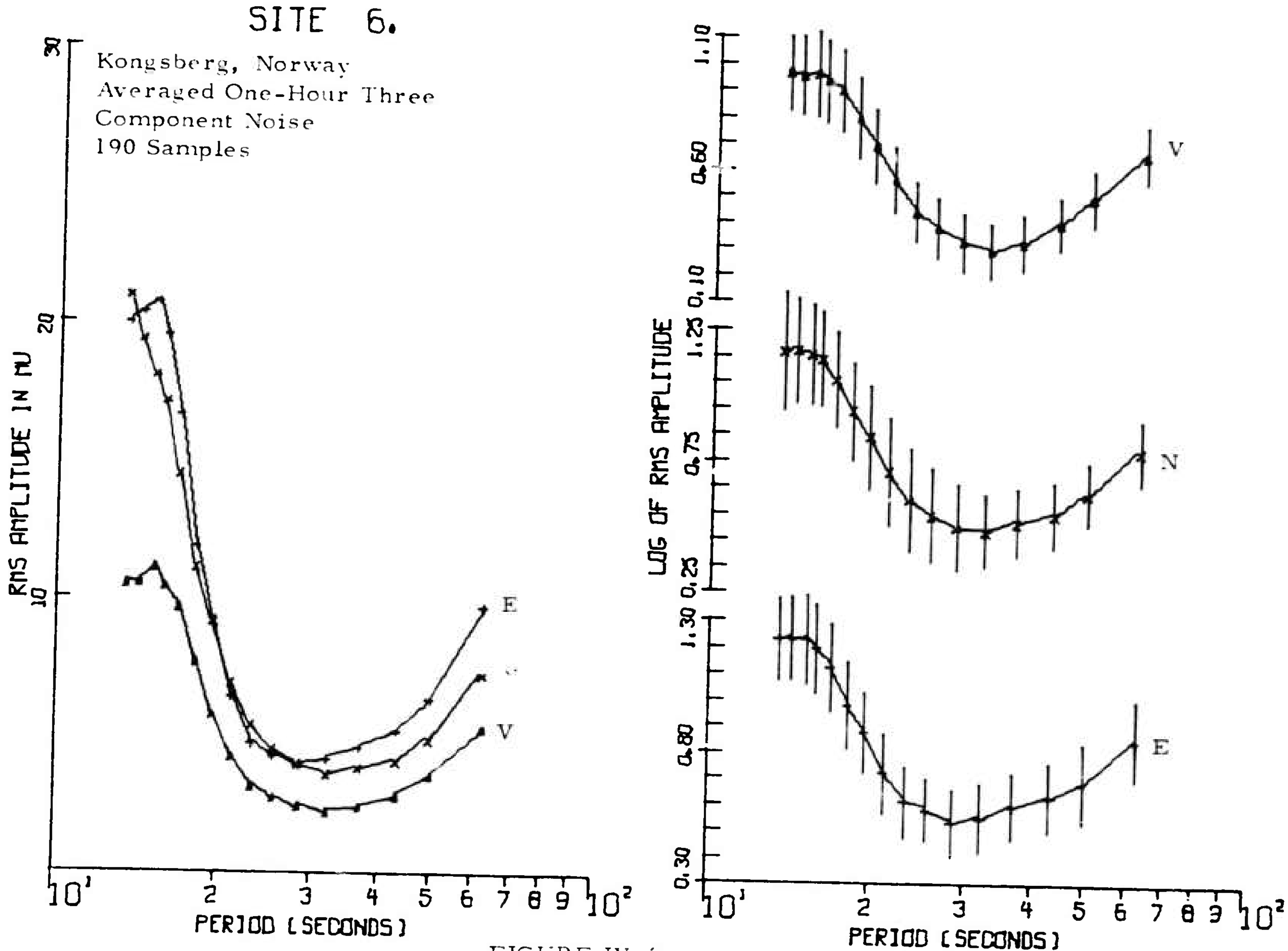

FIGURE IV-6

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION KON

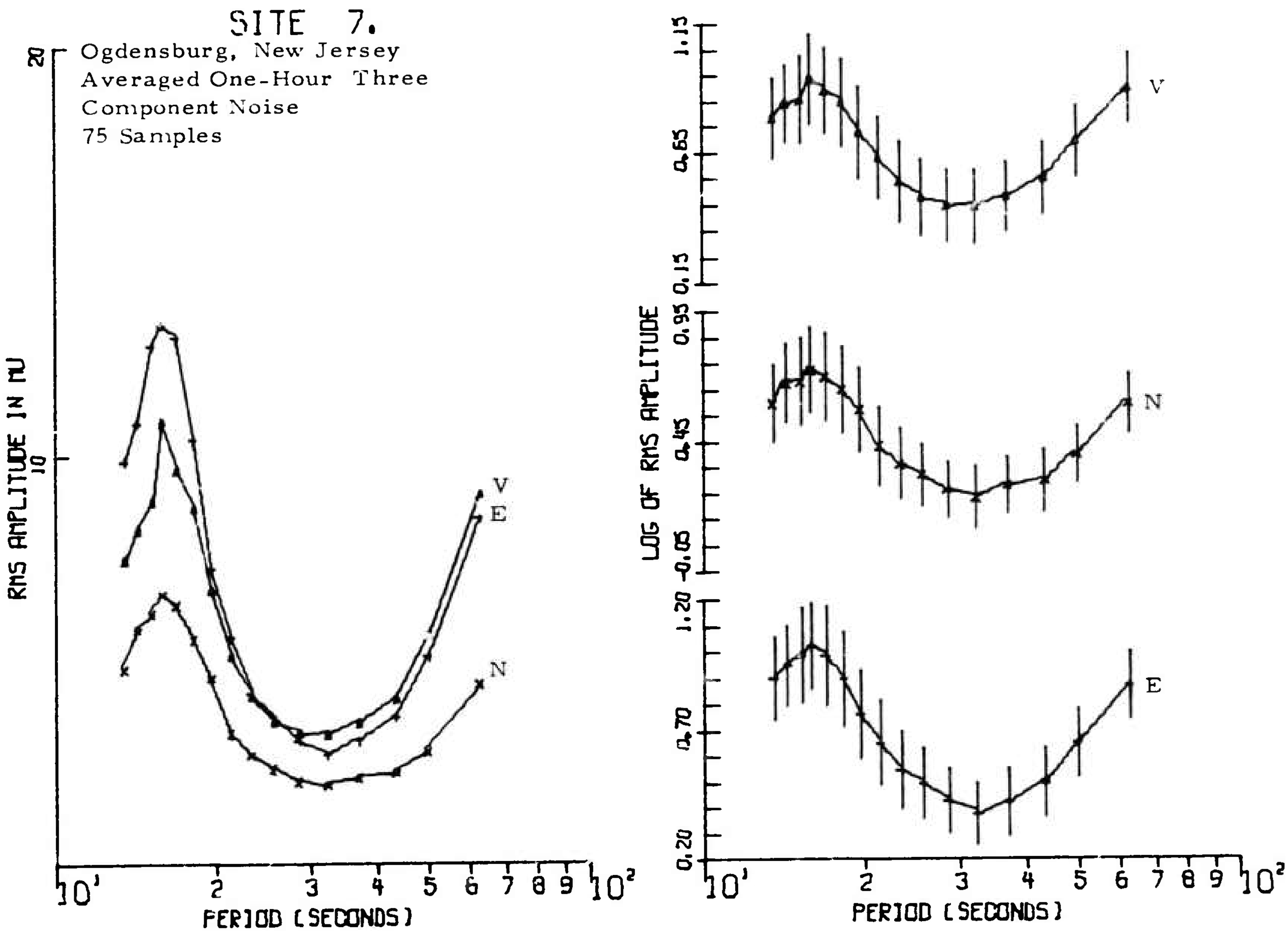

FIGURE IV-7

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION OGD

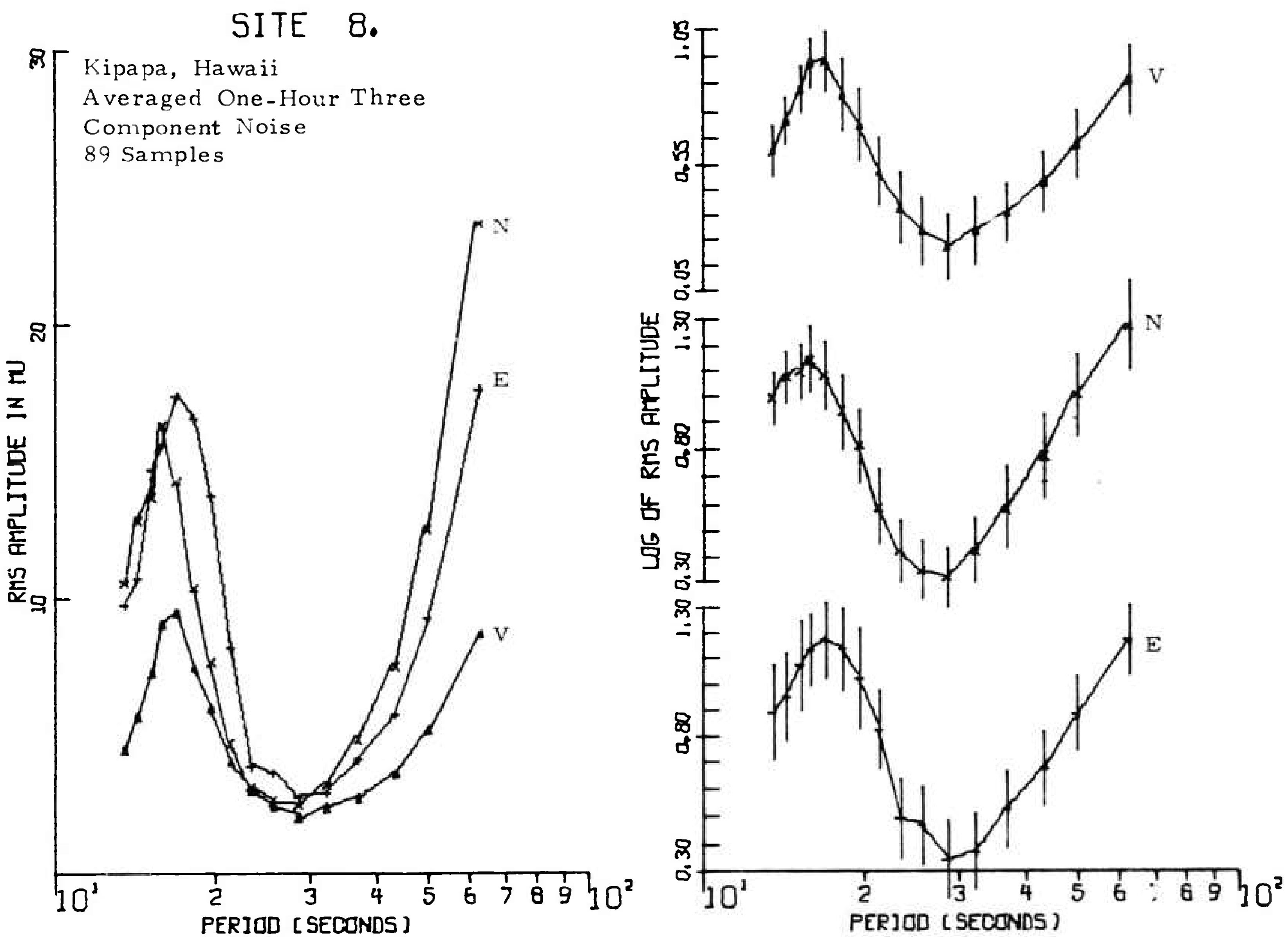

FIGURE IV-8

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION KIP

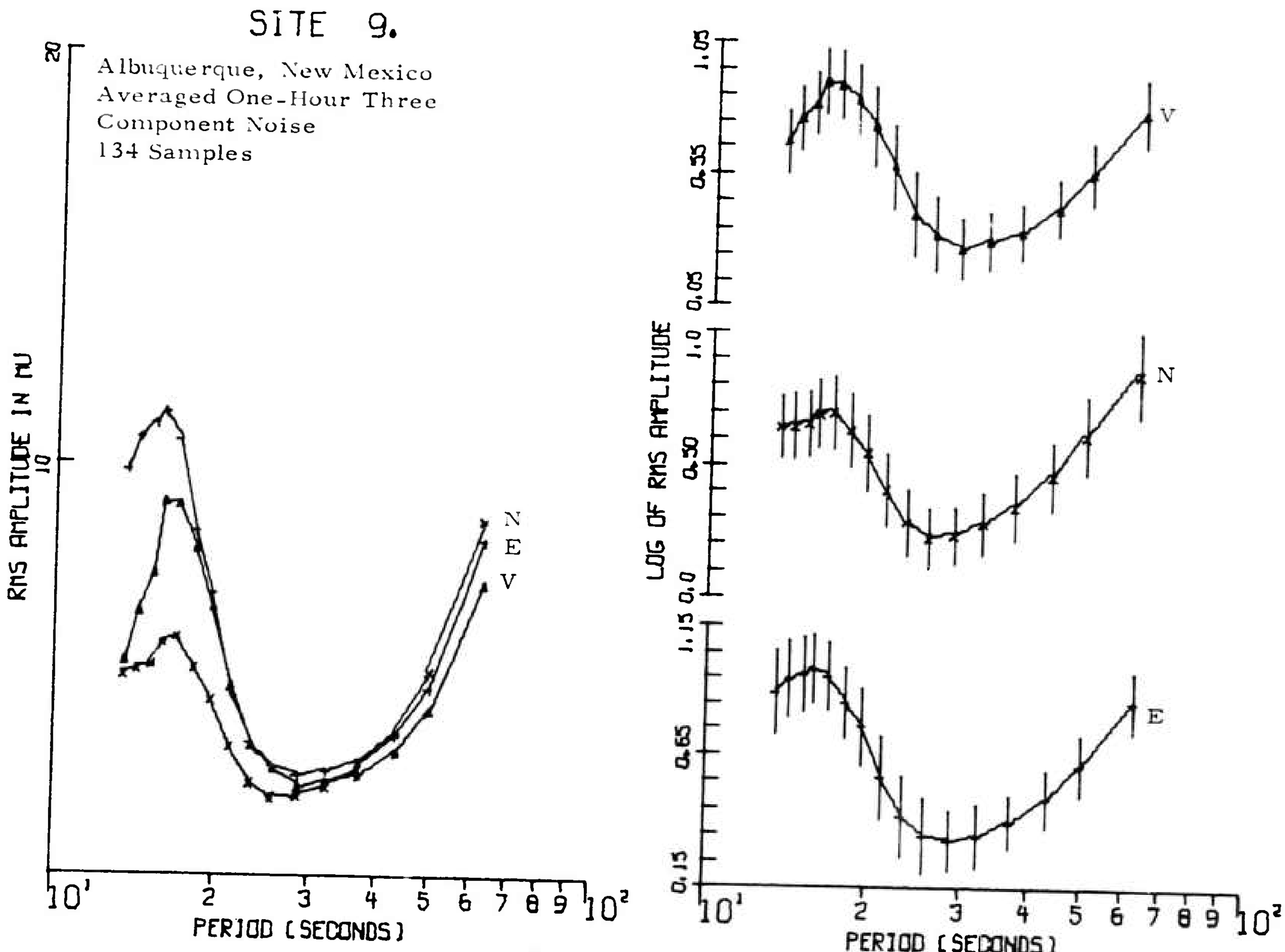

FIGURE IV-9

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION ALQ

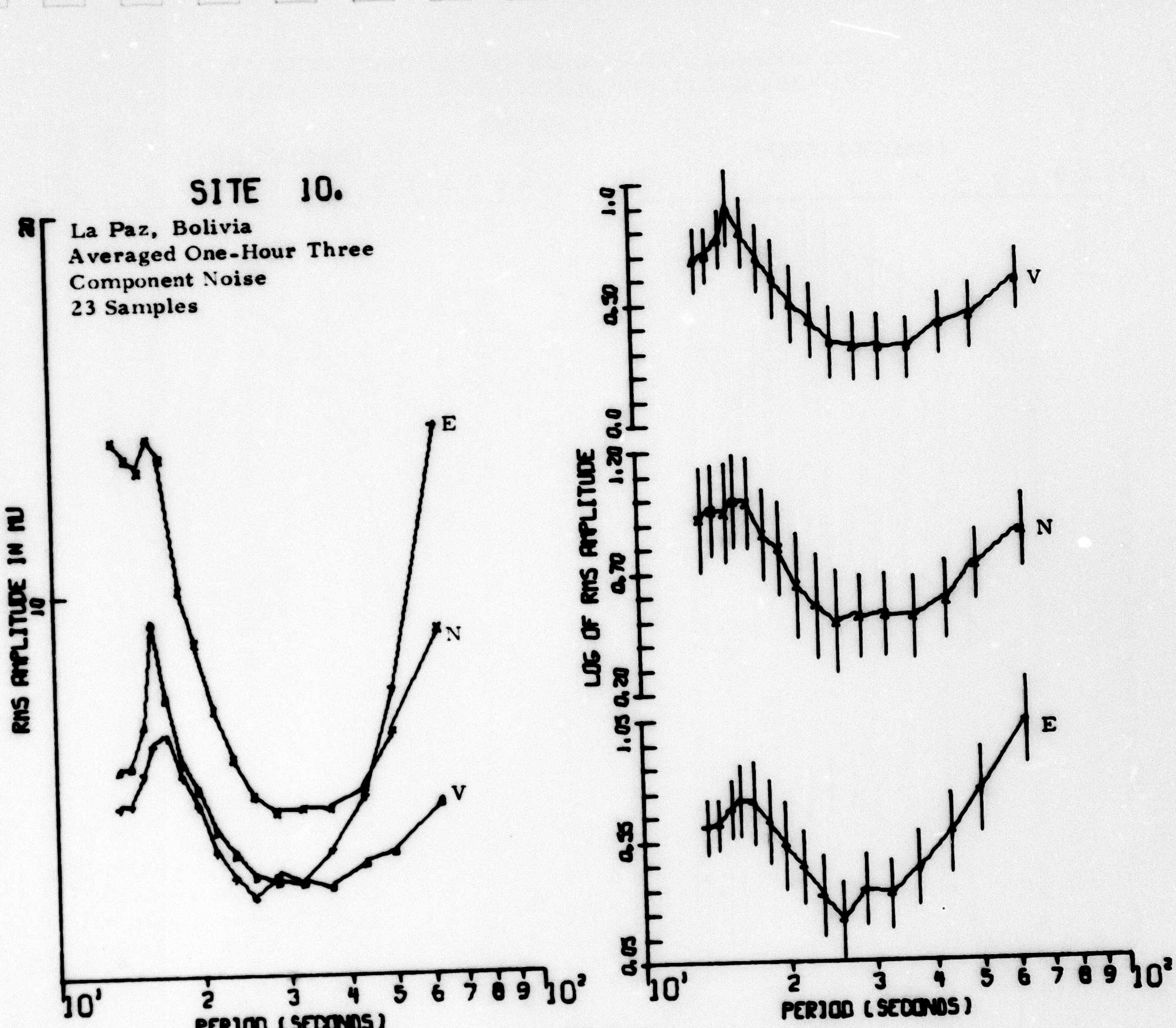

FIGURE IV-10

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION ZLP

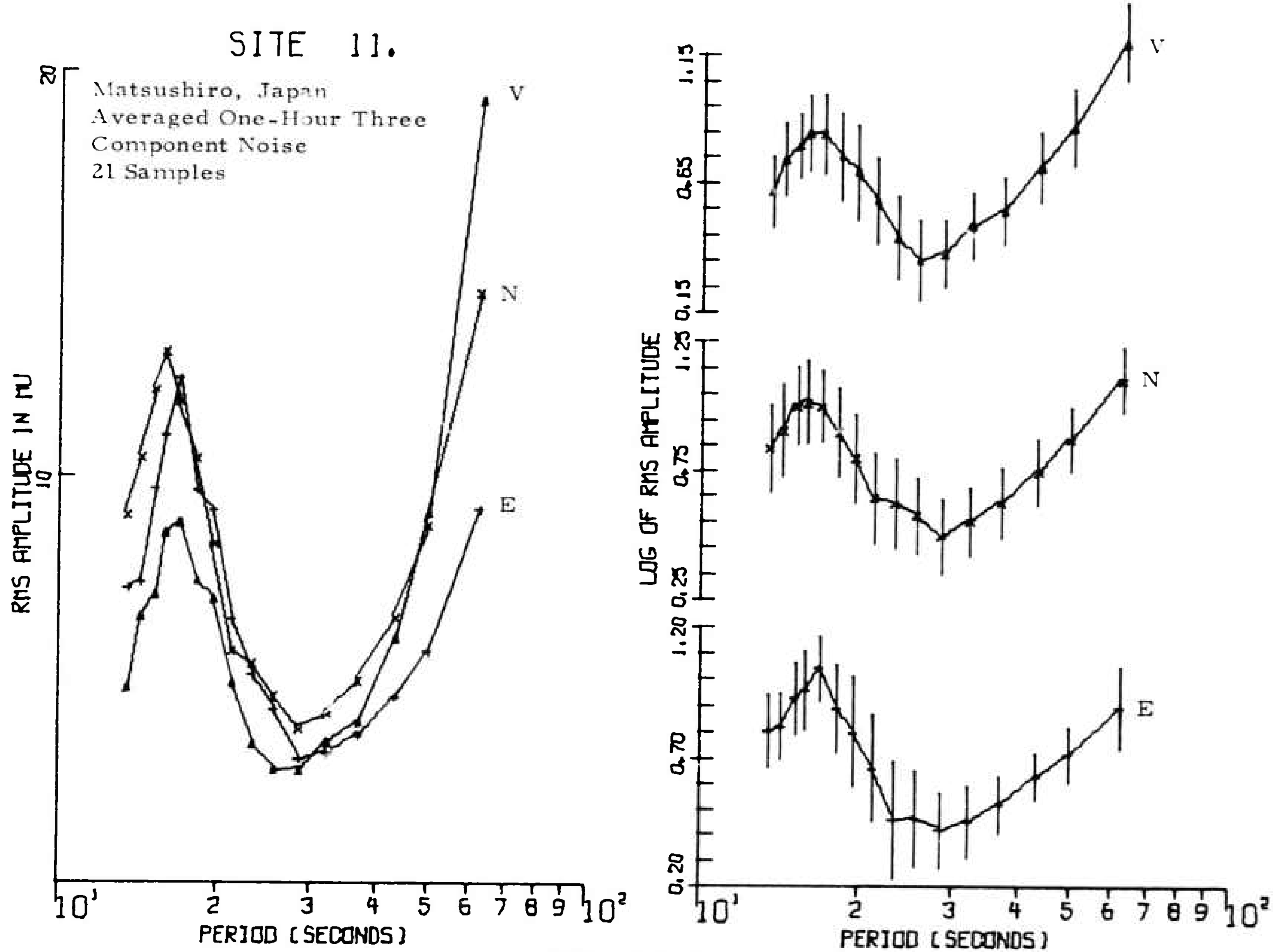

FIGURE IV-11

THREE COMPONENT RMS NOISE AMPLITUDE SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION MAT

The three component noise data show the following general characteristics:

- A microseismic peak was present in the neighborhood of 17 seconds period.
- The horizontal components RMS amplitudes were generally one to four times larger than the vertical component RMS amplitudes at periods greater than 35-50 seconds and periods less than 20-25 seconds.
- Variability of the RMS amplitudes appeared constant for all components throughout the period range of 13.5 to 62.5 seconds. This is contrary to results obtained by Alsup and Becker (1973a) and is likely a result of the larger data base and more stringent controls on the data quality.
- The bandwidth of the noise level minimum is defined as the period band in which the average RMS amplitudes are no greater than 3 dB above the minimum (Alsup and Becker, 1973a). The bandwidths of the noise minima for each component and station are given in Table IV-1. The minimum 'noise window' for the horizontal components is slightly narrower than for the vertical component. The average VLPE noise minimum bandwidth is approximately 22 to 42 seconds for all components and all stations together. This is somewhat greater than that reported by Murphy et al., (1973a).

Two notable abnormalities exist. First, stations TLO, EIL, and KON have atypical spectra for the N component. The microseismic peak at 17 seconds period was not readily observable. Second, at most stations the two horizontal component spectra differed substantially from each other. These results were unexpected assuming isotropic noise over the long term. Small

TABLE IV-1

THREE COMPONENT BANDWIDTHS OF NOISE MINIMA AT VERY LONG PERIOD EXPERIMENT STATIONS

Station	Vertical Component (Seconds)	North-South Component (Seconds)	East-West Component (Seconds)
CTA	25-46	22-41	23-41
CHG	25-44	22-40	22-42
FBK	23-40	23-39	21-35
TLO	23-41	25-39	21-35
EIL	18-35	? -30	19-31
KON	23-46	22-50	22-50
OGD	22-46	22-50	24-45
KIP	24-38	23-34	24-36
ALQ	23-43	22-39	23-42
ZLP	22-53	21-46	22-34
MAT	22-32	21-37	22-40

changes in the instrument response curves could account for all the horizontal component spectral discrepancies. Also, predominant year-round directional noise may be a factor.

C. COHERENCE

Linear intercomponent RMS noise amplitude correlations were reported by Alsup and Becker (1973b) and Lambert et al., (1973). Their results suggested that the VLPE components were uncorrelated. The correlation between components for these present data was measured by calculating coherence spectra for the three two-component pairs.

The squared coherence, R^2, between the x and y components is defined as follows:

$$R^2 = \frac{\phi_{xy}(f)\,\phi_{yx}(f)}{\phi_{xx}(f)\,\phi_{yy}(f)} = \frac{\left|\phi_{xy}(f)\right|^2}{\phi_{xx}(f)\,\phi_{yy}(f)}$$

where $\phi_{xx}(f)$ and $\phi_{yy}(f)$ are the autopower spectrum functions of components x and y, and $\phi_{xy}(f)$ is the crosspower spectrum function between components x and y. R^2 satisfies $0 \leq R^2 \leq 1$ for all real frequencies.

Estimates of R^2 were calculated for each station, using the above formula, from three component noise data at 16 discrete periods covering 13.5 to 62.5 seconds for all three two-component combinations. Each two-component combination set then was averaged over a number of samples randomly chosen from those samples available for that station.

The mean value of R^2, averaged over all stations, samples, period values, and two-component combinations (i.e., 395 samples x 16 periods x 3 two-component sets), was 0.21. Haubrick (1965) and Amos and Koopman (1963) show that for this expected R^2 of 0.21 and approximately

28 degrees of freedom, the population or true sample squared coherence equals 0.16 if 95 percent of the calculated R^2 values are within confidence limits of $0.06 \leq R^2 \leq 0.49$. The two factors contributing to the degrees of freedom were the number of segments used in Fourier transforming the noise data and the application of a Hanning operator to the transforms.

Ninety five percent of the R^2 values clearly fell within the confidence limits. It is questionable whether an attempt to process VLPE components using an intercomponent coherence processor would be worthwhile as the squared coherence values indicate that only 16 percent of the power in one component can be predicted from the power in another component. It is emphasized that the major assumption for the validity of the above calculations is that the statistics of the noise observations are stationary for a finite time interval.

Figures IV-12 through IV-22 are plots of squared coherence, R^2, versus period. In general, all VLPE stations displayed similar coherence characteristics with a relatively constant value for all components over the entire period range of 13.5 to 62.5 seconds. There was a tendency toward increased values in the 15-25 seconds period range at most stations and occasionally in the 30-50 seconds period range, suggesting that the long-term noise field has a small directional component. Therefore, the average long-term noise field is composed of mainly isotropic noise. However, any conclusions based on these data are very weak.

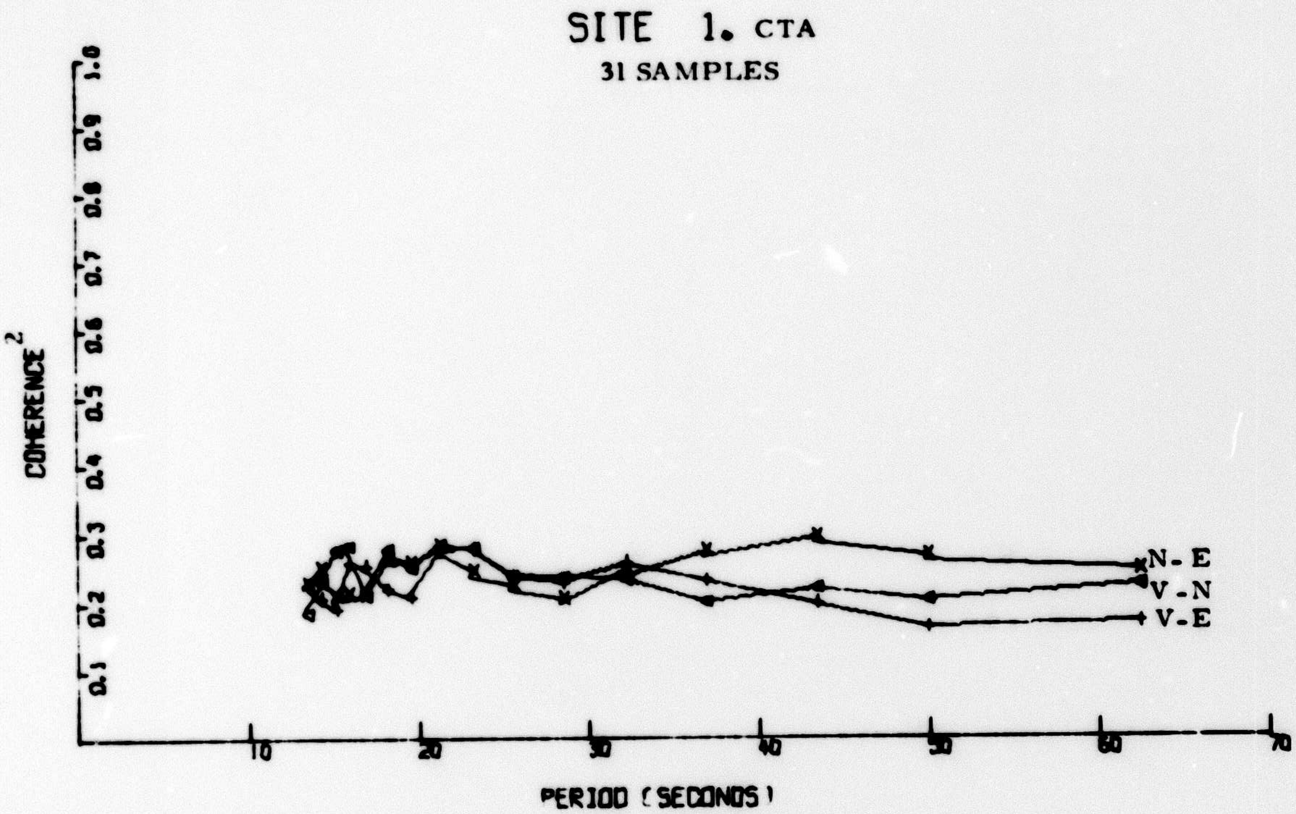

FIGURE IV-12

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION CTA

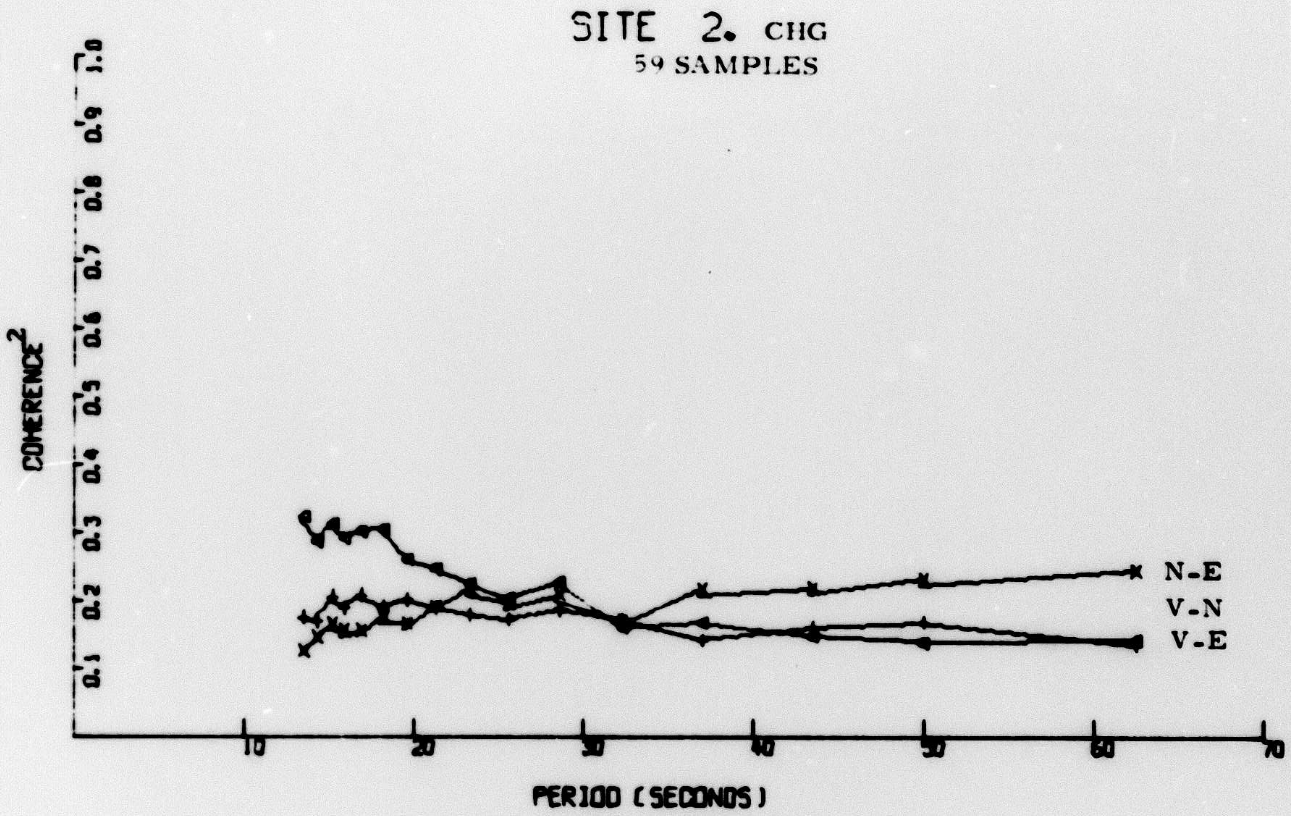

FIGURE IV-13

TWO COMPONENT COHERENCE SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION CHG

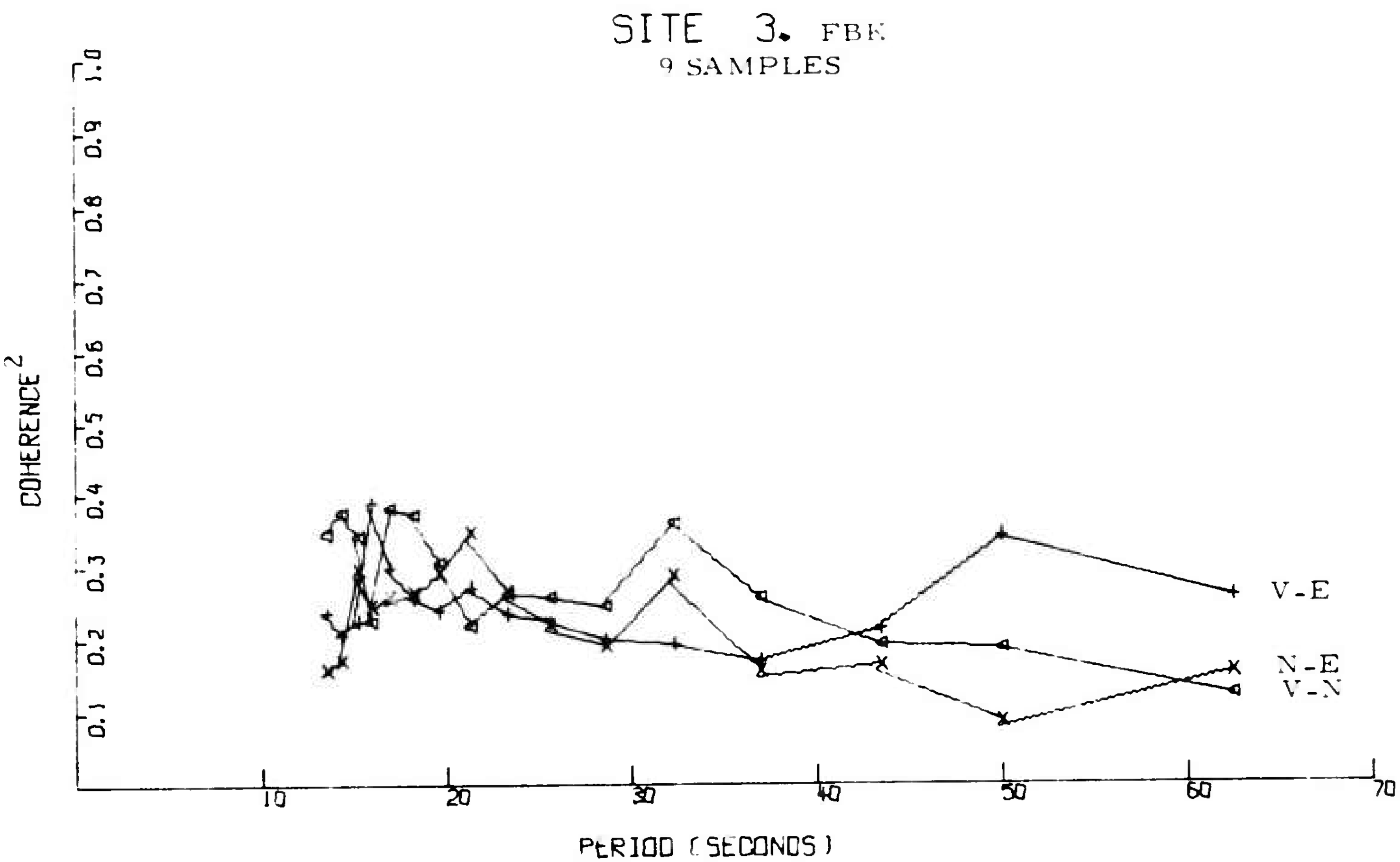

FIGURE IV-14

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION FBK

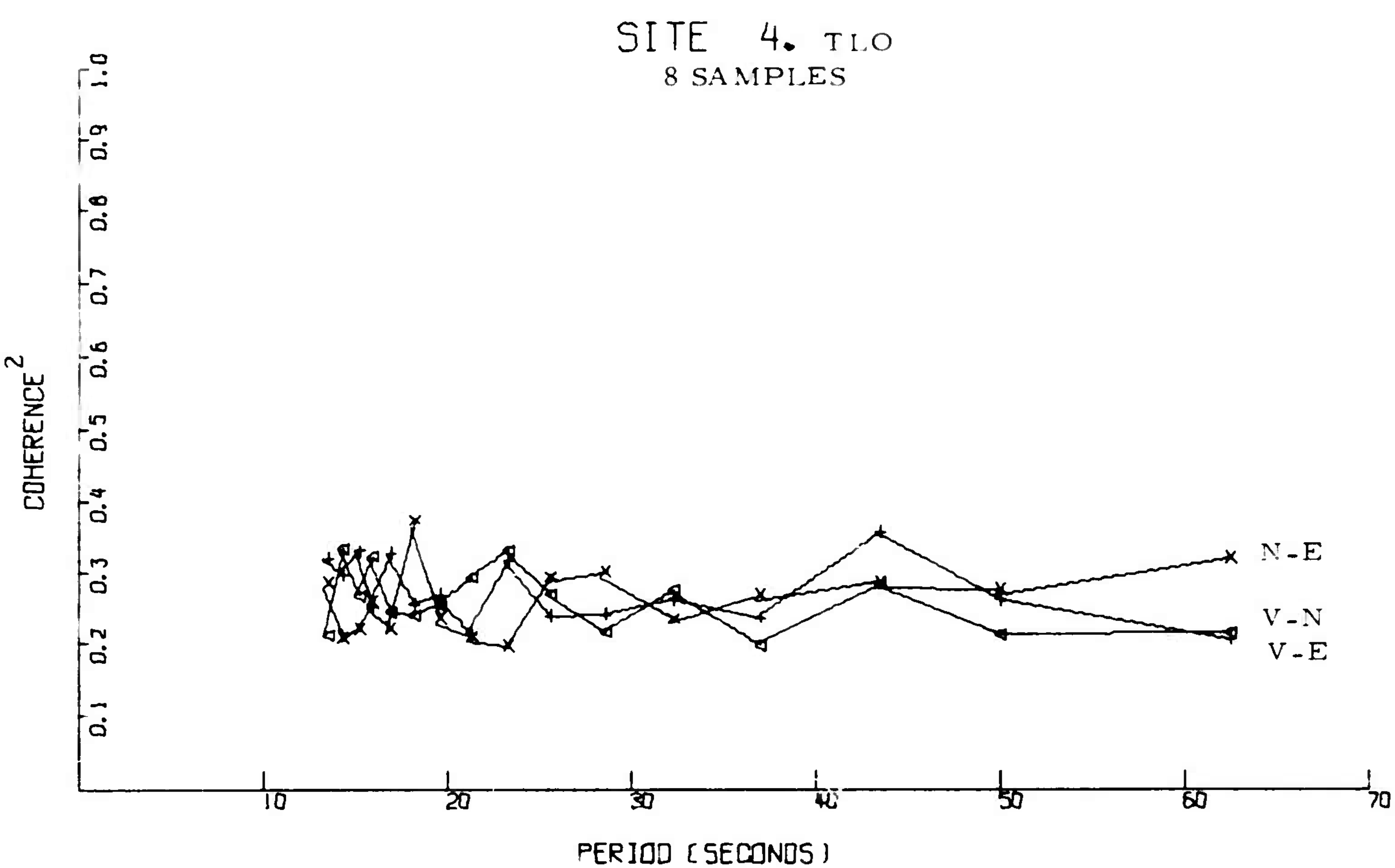

FIGURE IV-15

TWO COMPONENT COHERENCE-SQUARED SPECTRA AT VERY LONG PERIOD EXPERIMENT STATION TLO

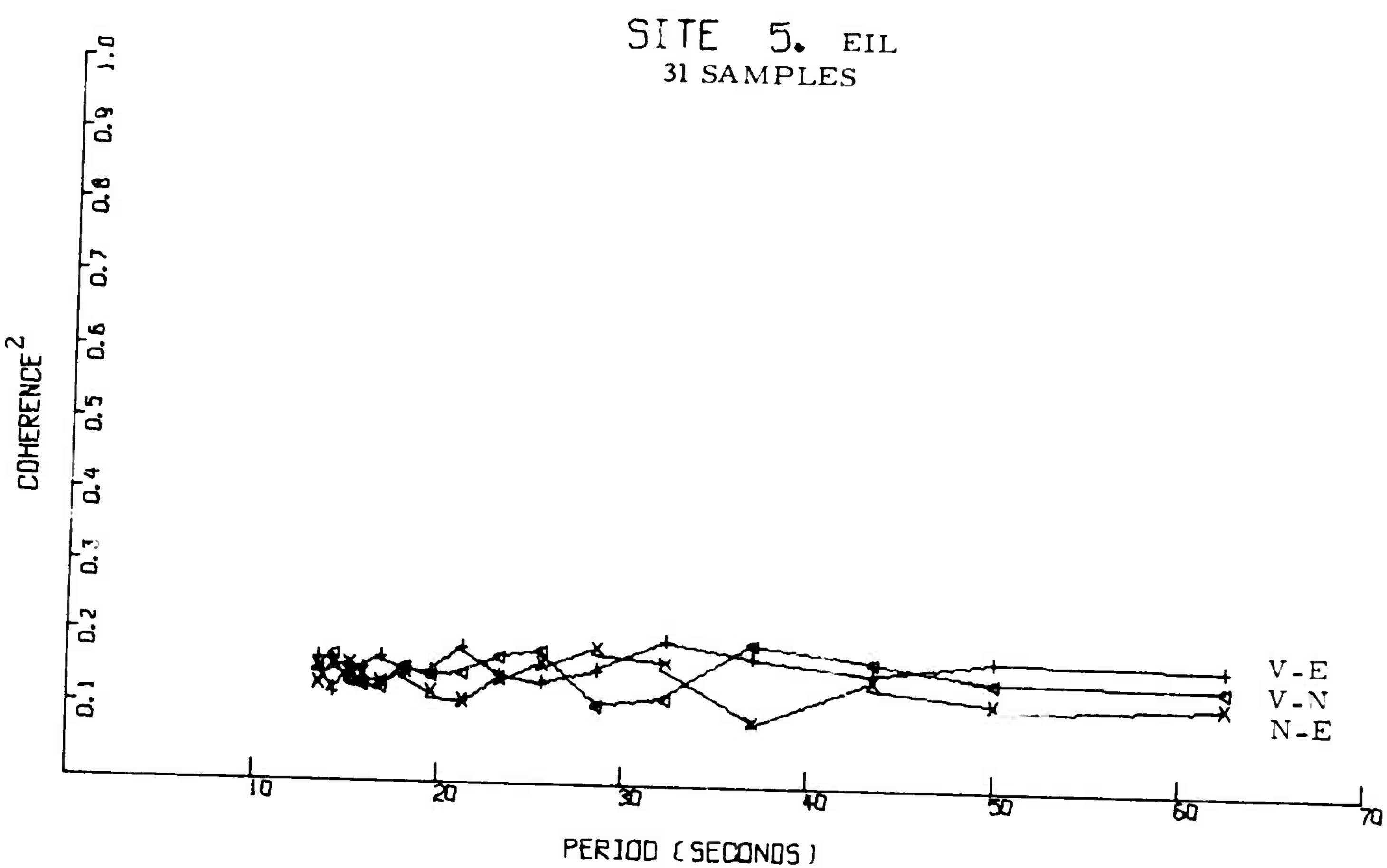

FIGURE IV-16

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION EIL

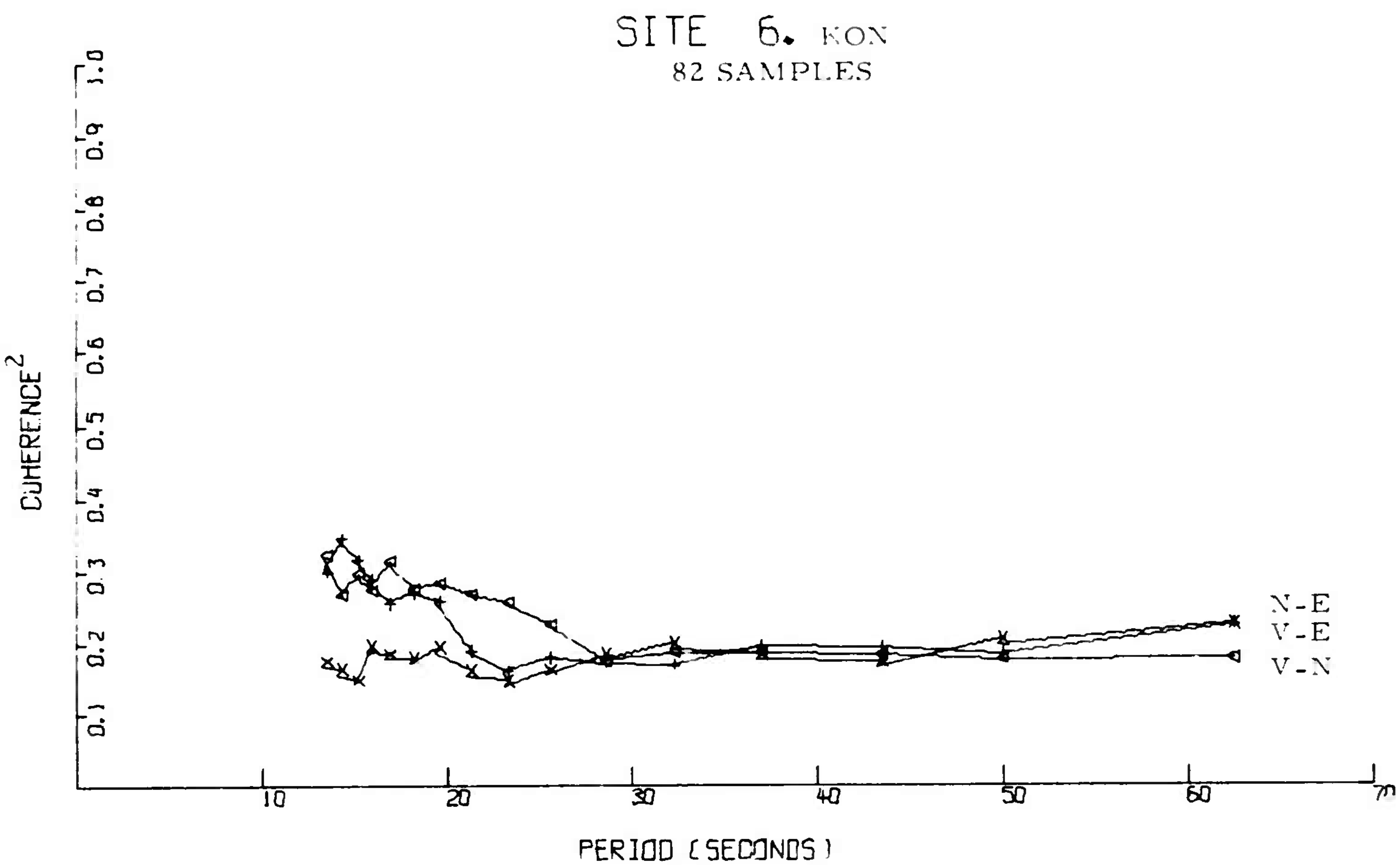

FIGURE IV-17

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION KON

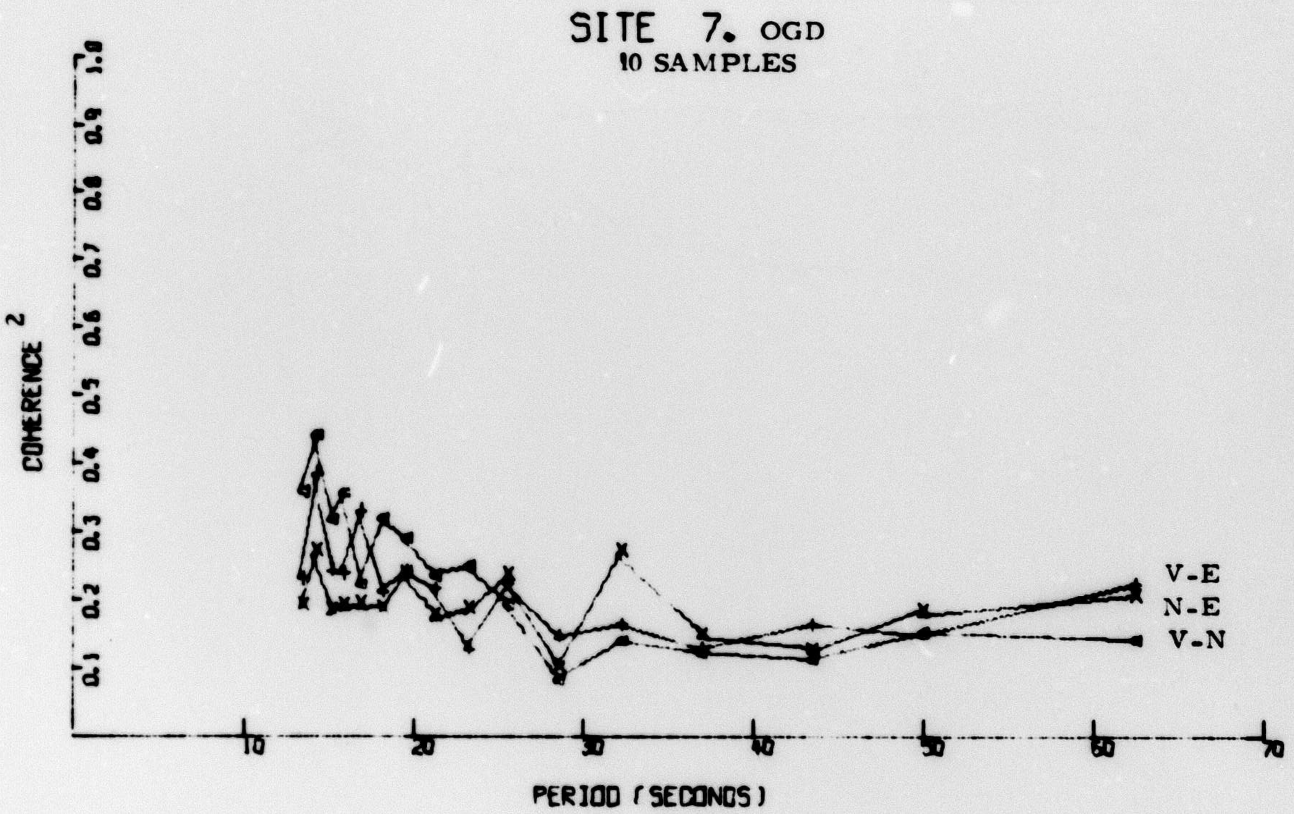

FIGURE IV-18

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION OGD

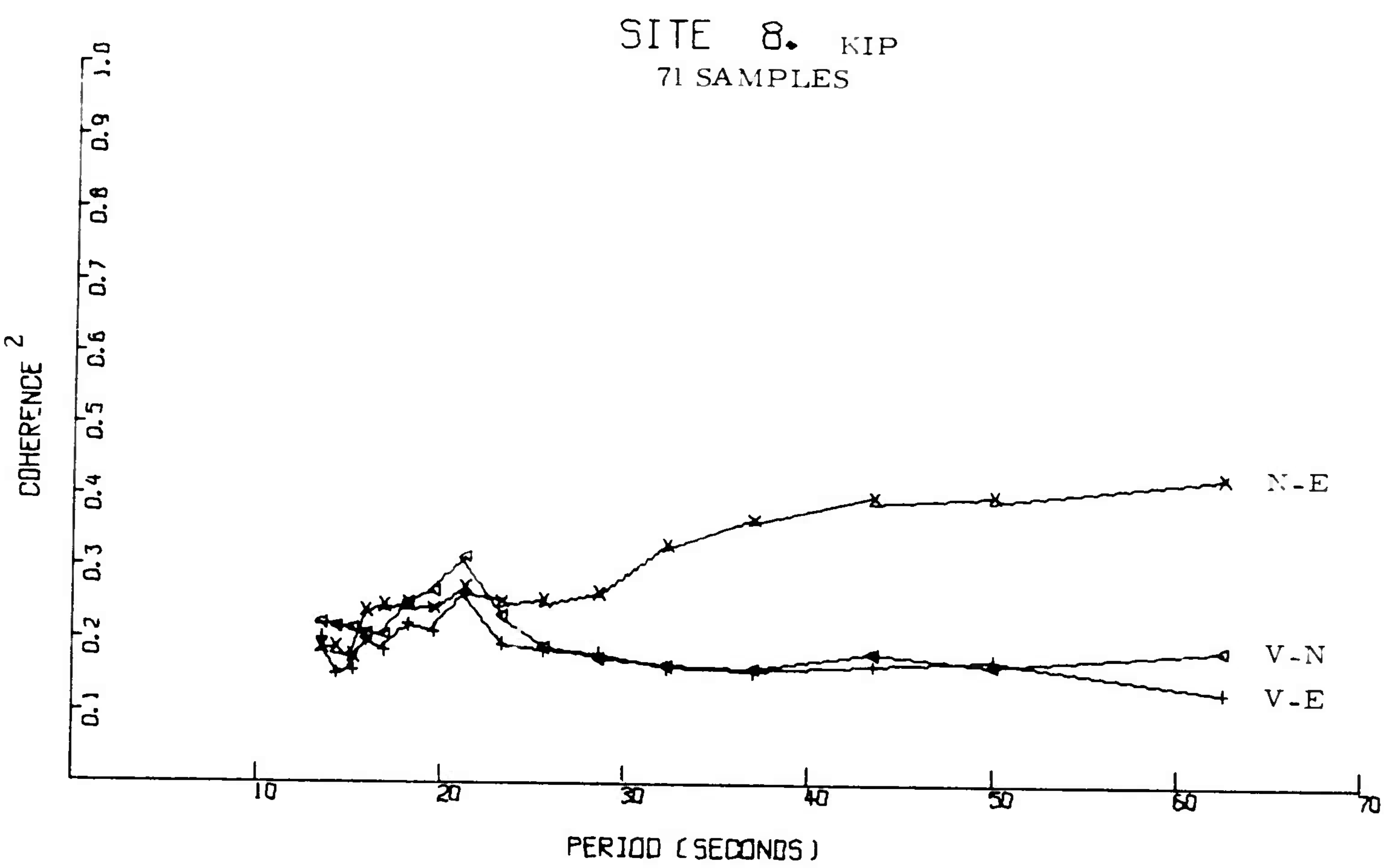

FIGURE IV-19

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION KIP

SITE 9. ALQ
60 SAMPLES

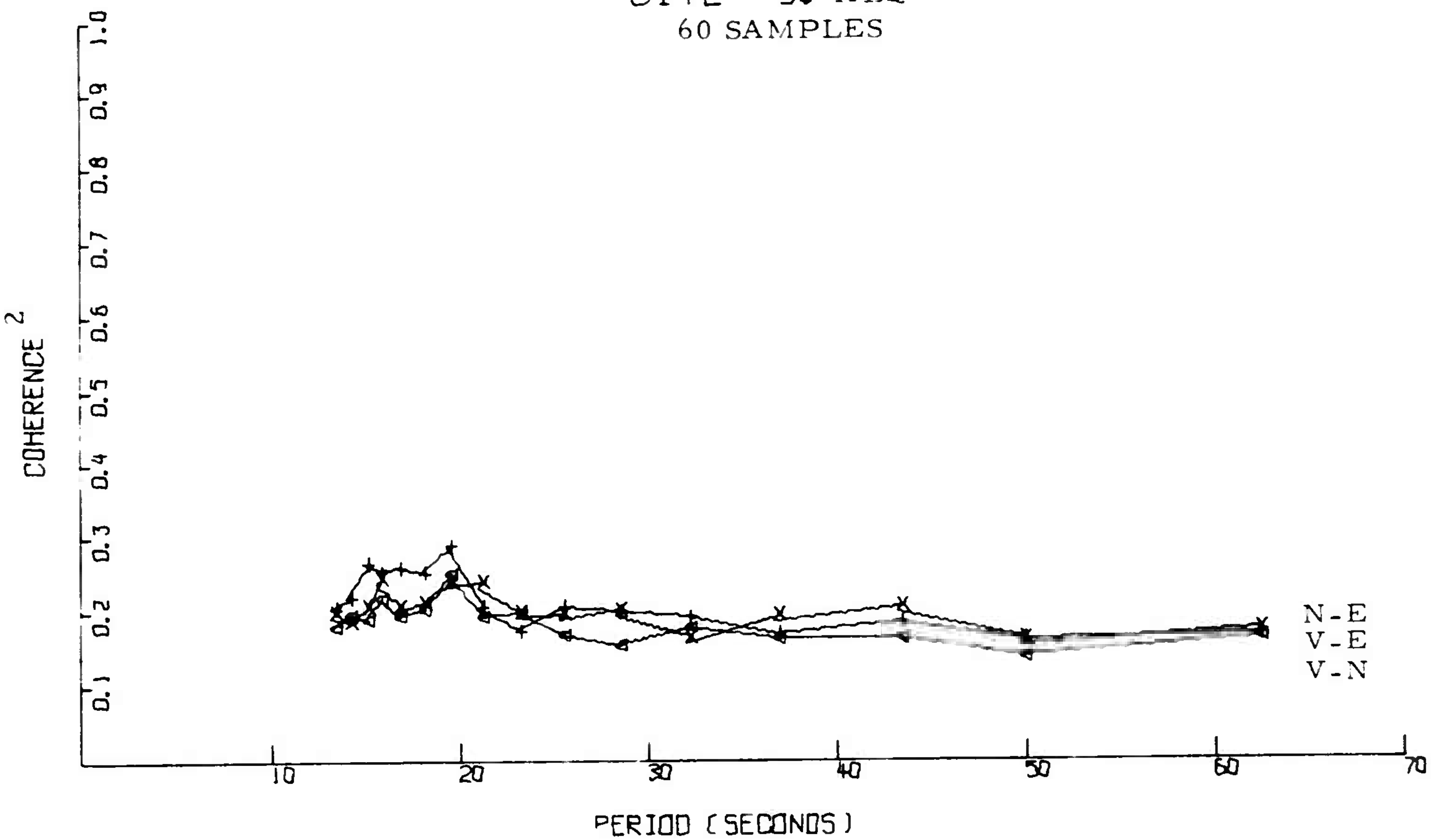

FIGURE IV-20

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION ALQ

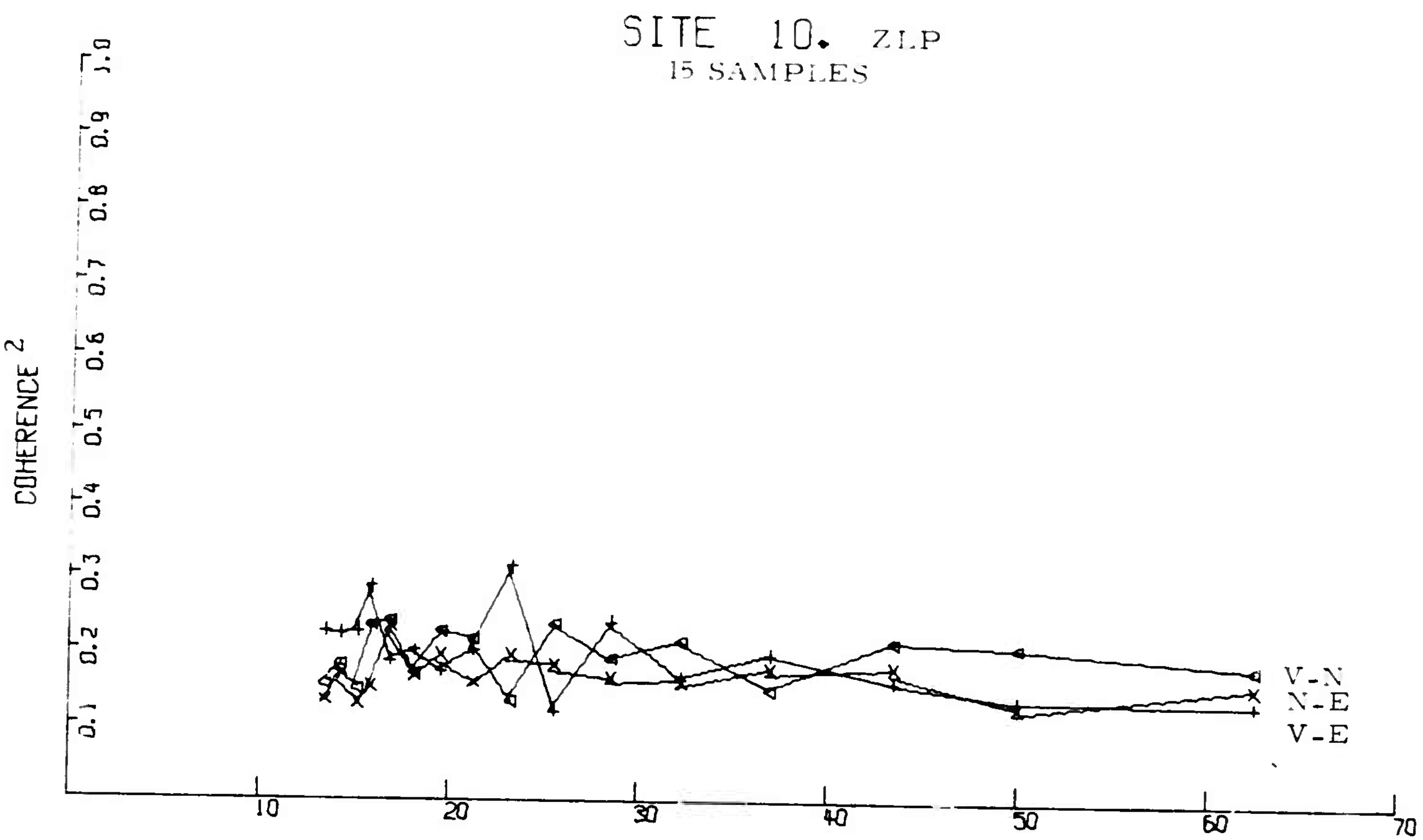

FIGURE IV-21

TWO COMPONENT COHERENCE-SQUARED SPECTRA AT VERY LONG PERIOD EXPERIMENT STATION ZLP

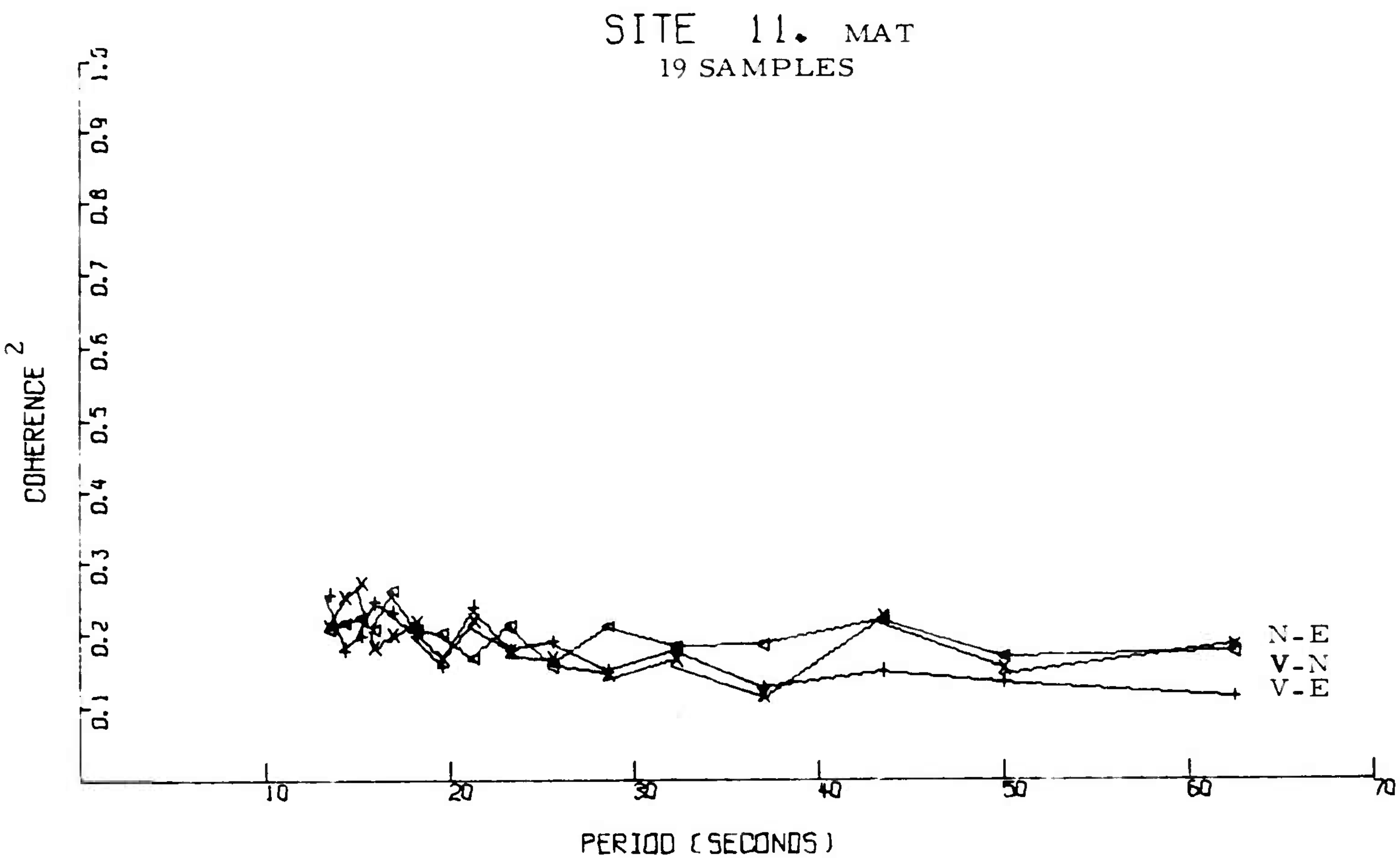

FIGURE IV-22

TWO COMPONENT COHERENCE-SQUARED SPECTRA
AT VERY LONG PERIOD EXPERIMENT STATION MAT

SECTION V

SUMMARY AND CONCLUSIONS

The main results and conclusions from this study are summarized below:

1. Data Base

- For the period from January 1972 through March 1973, 2734 hours of noise data from all VLPE stations were available. Only 1503 (55%) had usable vertical component data and 846 (31%) had usable three component data. Thus, overall data quality was relatively poor.

- In order to avoid visual inspection of large numbers of plots acceptance criteria on the basis of RMS amplitudes and power densities were developed. However, an estimated 10% of the noise samples passing the criteria still contain non-seismic noise. Station EIL was subjected to less stringent acceptance criteria in order to obtain enough samples for analysis.

2. Vertical Component Noise Analysis

- The average base levels in the 17-25, 20-40, and 30-40 seconds period bands of the vertical component noise data for all VLPE stations were 14.5, 10.1, and 4.5 mμ, respectively, showing the stable minimum at 30-40 seconds periods observed in previous studies.

- The approximate ordering of VLPE stations from quietest (lowest vertical component RMS amplitudes) to noisiest (highest vertical component RMS amplitudes) was as follows: ZLP, CHG, KIP, ALQ, FBK, TLO, EIL, MAT, KON, OGD, and CTA.

- The small quantity and uneven distribution of the vertical component noise data prevented conclusive statements about the long-term (seasonal) variations in the RMS amplitudes at any VLPE stations except station KON which showed definitely increased RMS amplitudes during the winter period.

3. Three Component Noise Analysis

- Variability of the RMS amplitudes appeared constant throughout the period range of 13.5 to 62.5 seconds for all components, which is contrary to previous results. This difference is due probably to the more stringent acceptance criteria and larger data base.

- Within the average minimum noise band of 22-42 seconds, the horizontal component spectra were remarkably similar to the vertical component spectra in amplitude, variability, and spectral shape. Outside this band the horizontal RMS amplitudes were generally one to four times larger than the vertical RMS amplitudes.

- Assuming time stationarity of the noise observations, all components of all VLPE stations were only weakly coherent, suggesting that the average long-term noise field is composed of mainly isotropic noise.

SECTION VI
REFERENCES

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